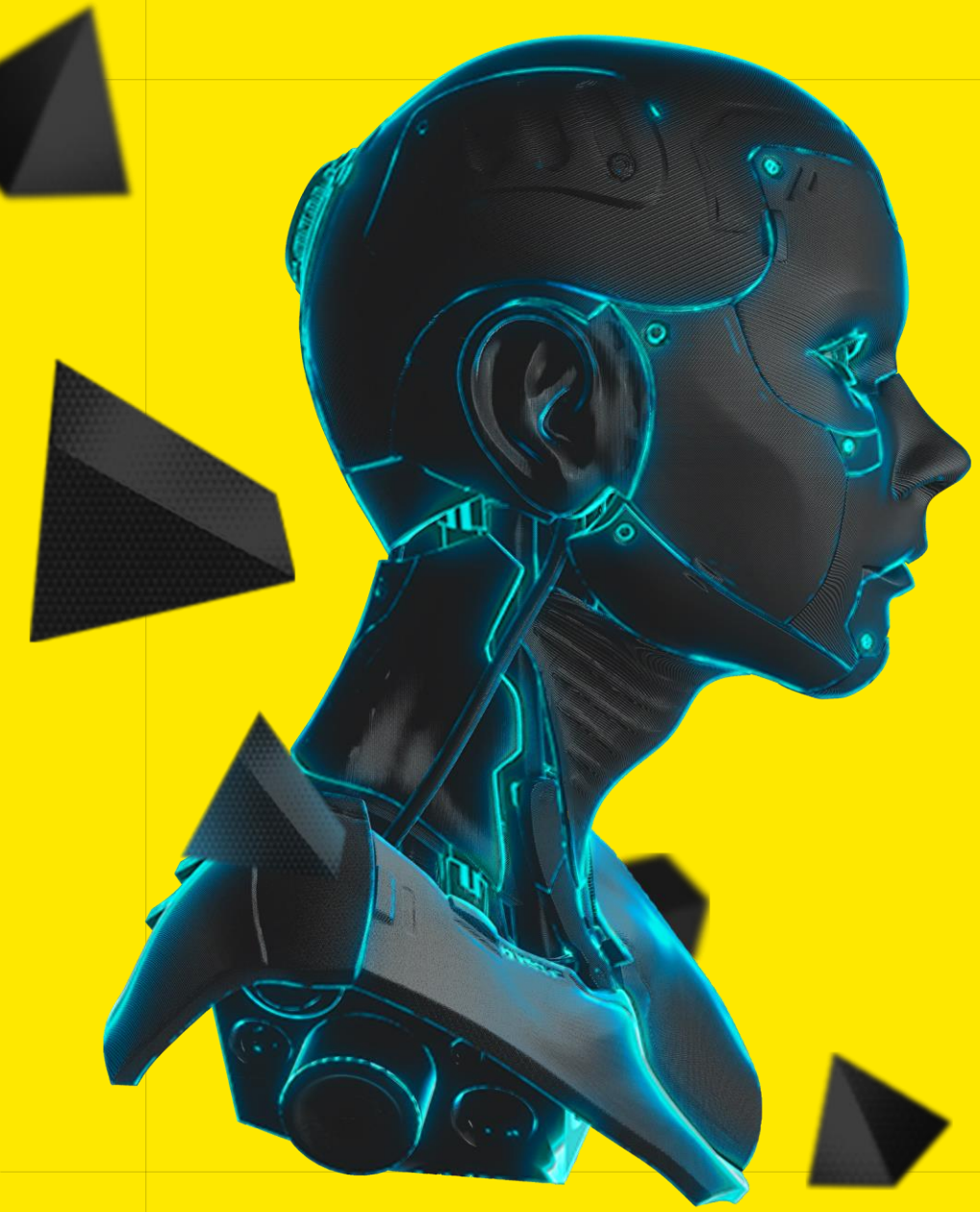

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NEURAL COMPLEX LUMINAIRES: REPRESENTATION AND RENDERING

Junqiu Zhu[1], Yaoyi Bai[2], Zilin Xu[1], Steve Bako[2], Edgar Velázquez-Armendáriz[3], Lu Wang[1], Pradeep Sen[2], Miloš Hašan[4], Ling-Qi Yan[2]

[1]Shandong University [2]University of California, Santa Barbara

[3]Pure Storage [4]Adobe Research

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THE PREMIER **CONFERENCE** & **EXHIBITION** IN
COMPUTER GRAPHICS & INTERACTIVE TECHNIQUES

COMPLEX LUMINAIRE

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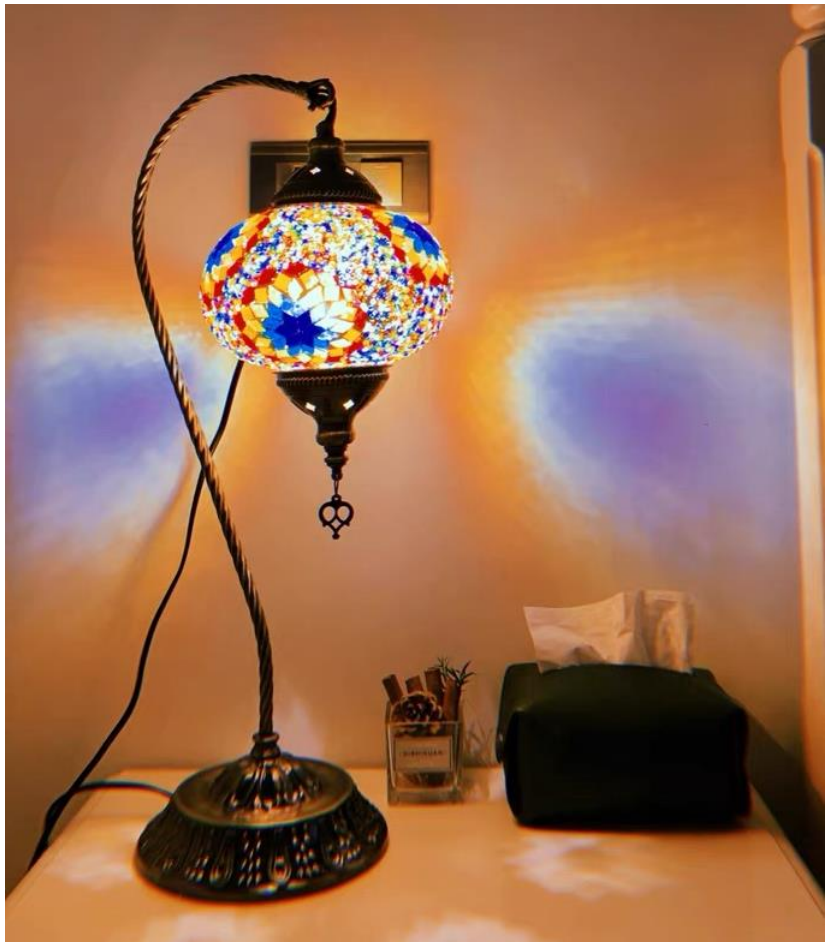
COMPLEX LUMINAIRE



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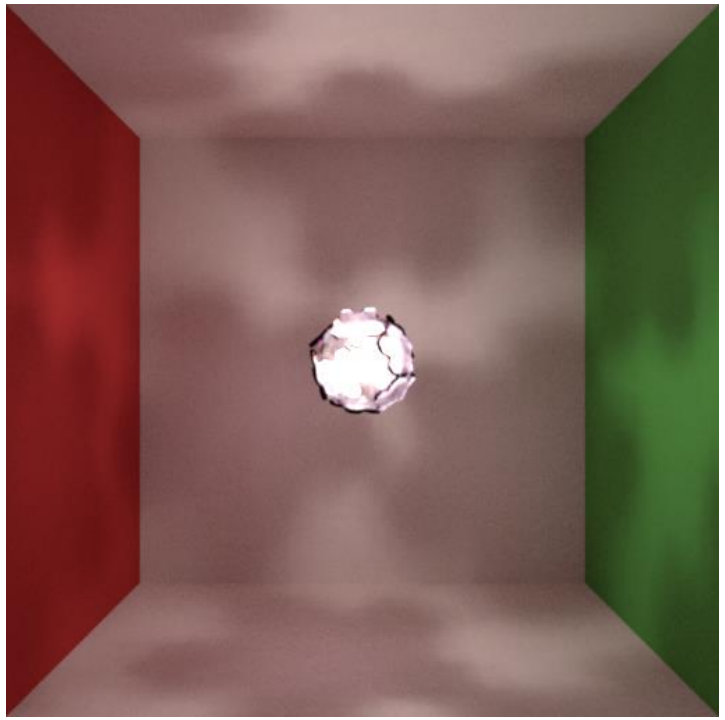
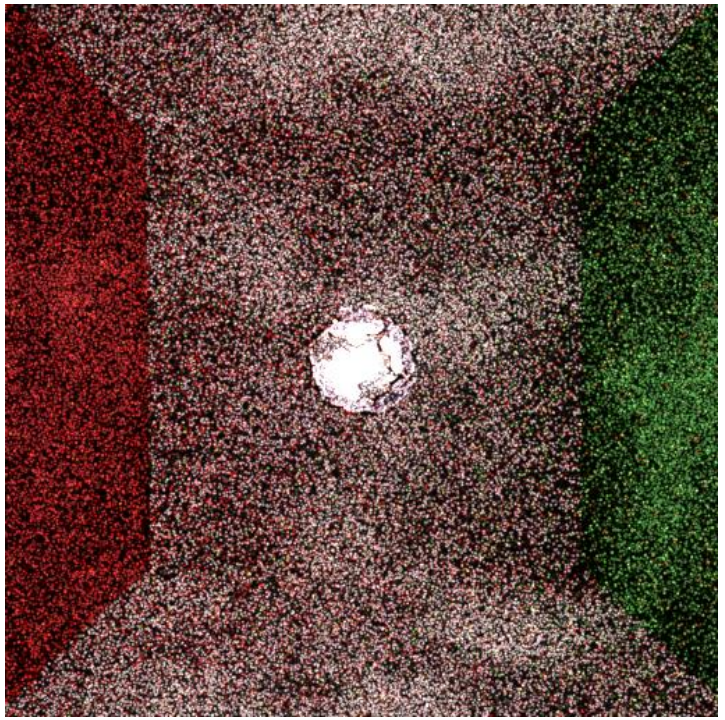
MOTIVATION

our method 64spp



path tracing 1024spp



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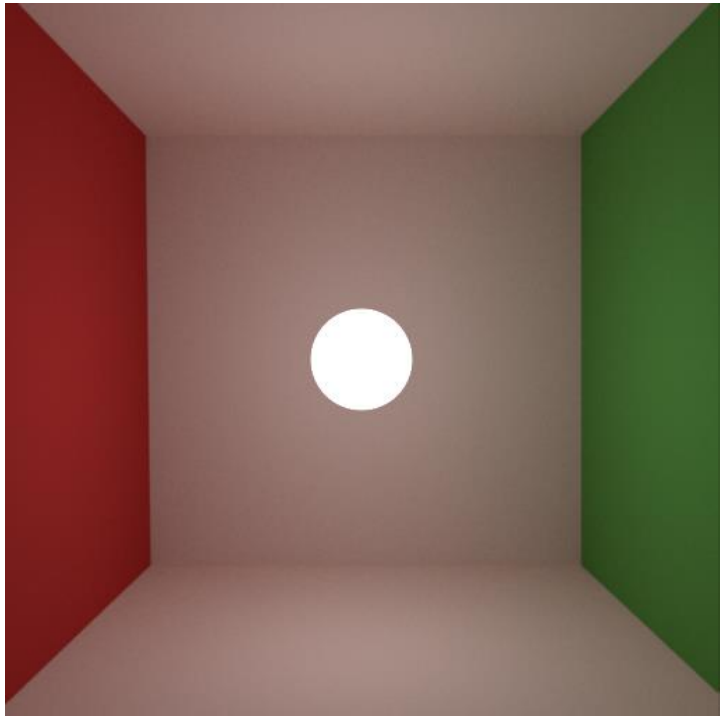
MOTIVATION

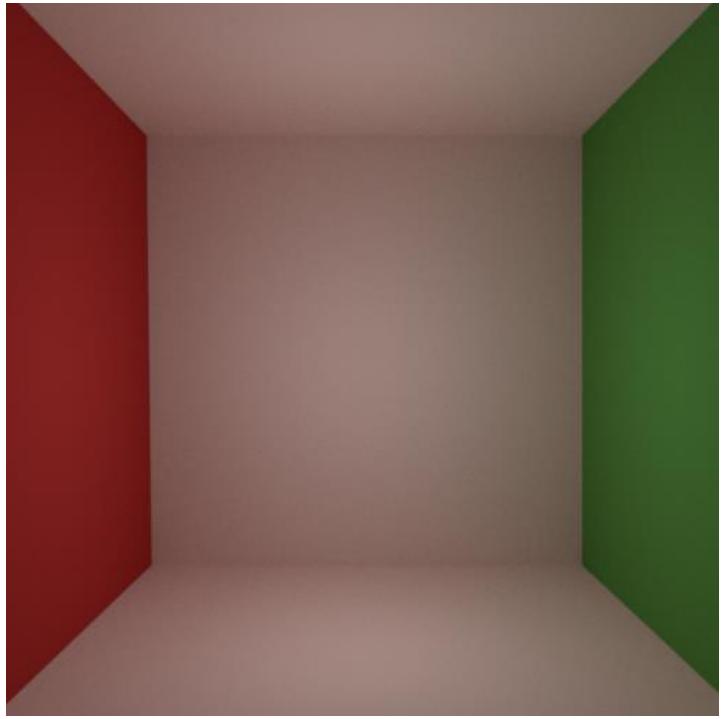
Area light

path tracing 64spp



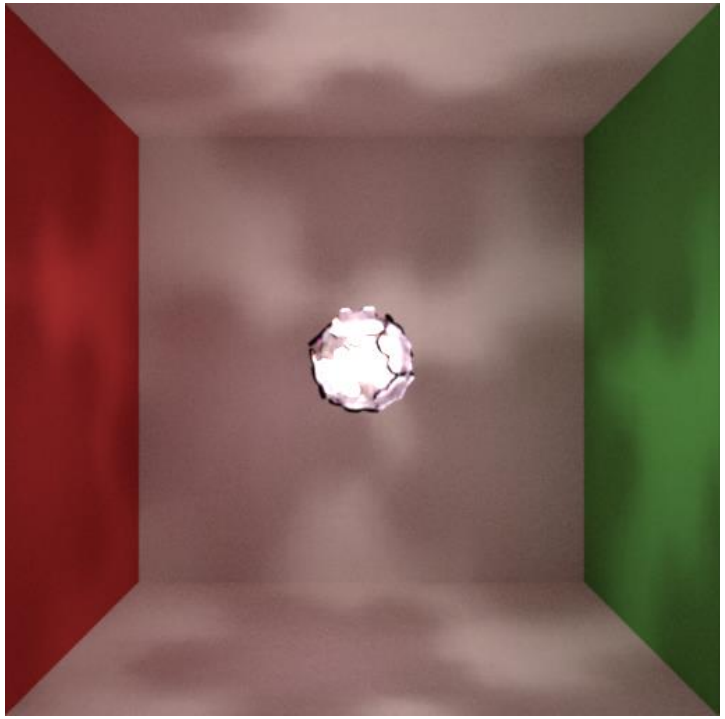
Point light

path tracing 64spp



Complex luminaire

our method 64spp



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MOTIVATION

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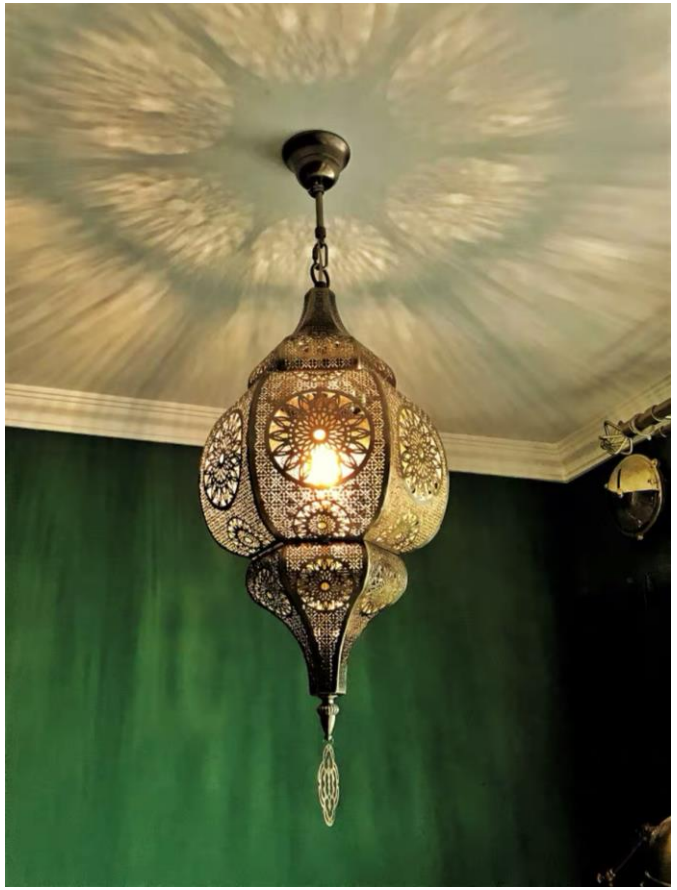
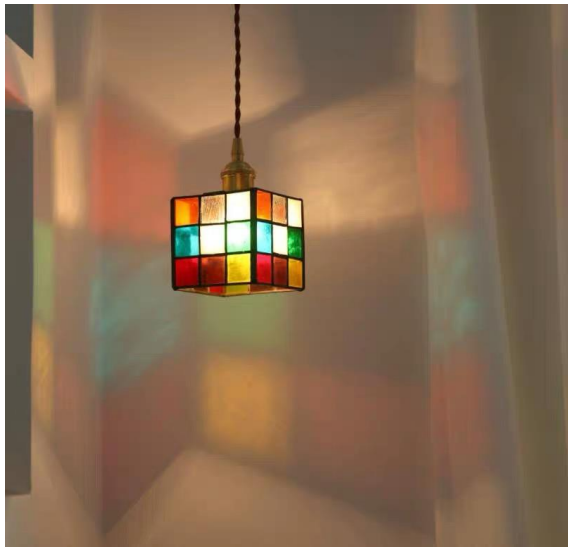
- *Difficult to render*
- *Large storage*
- *Copyright protection*





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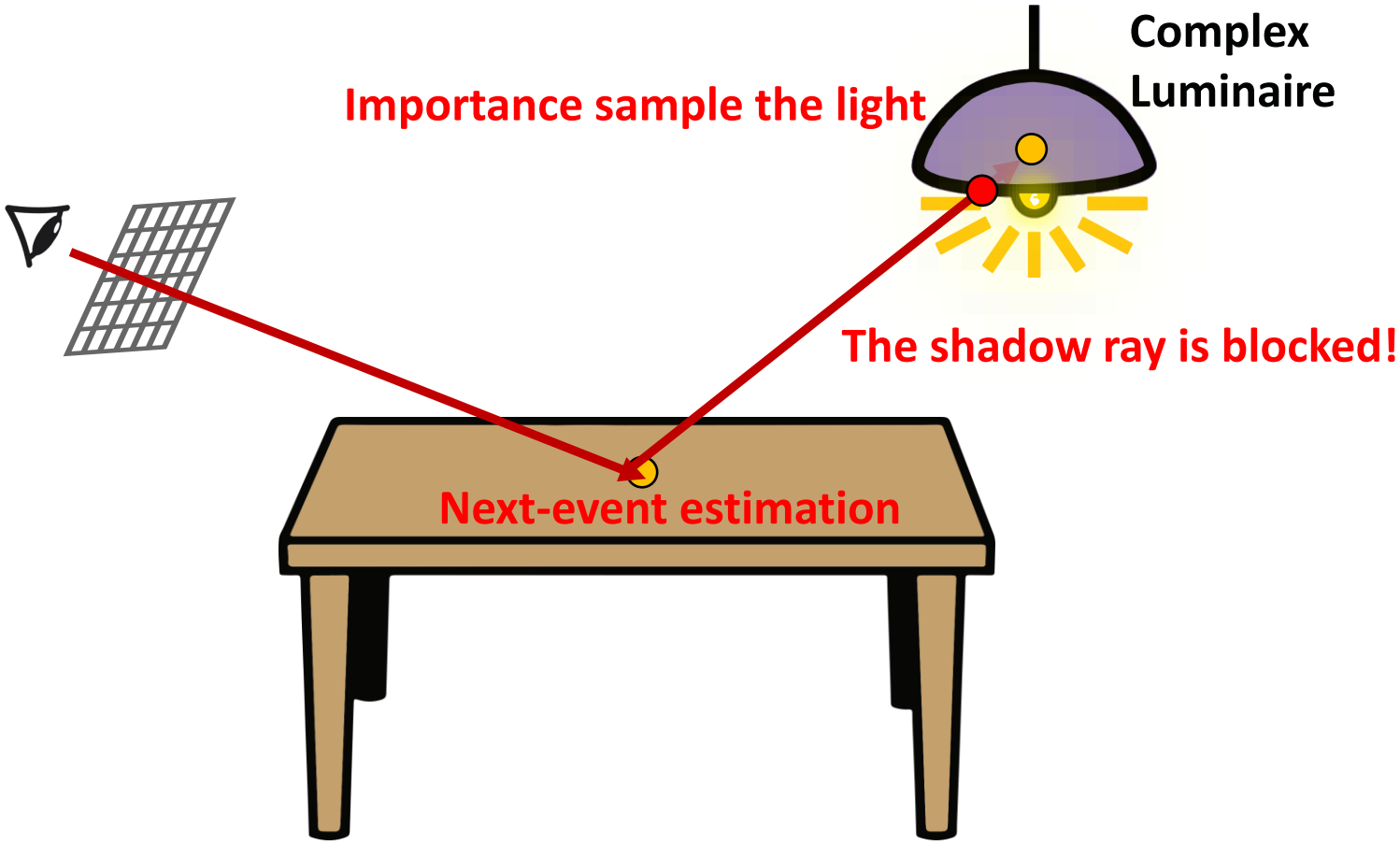
PROBLEMS

Complex geometries

Complex light transport



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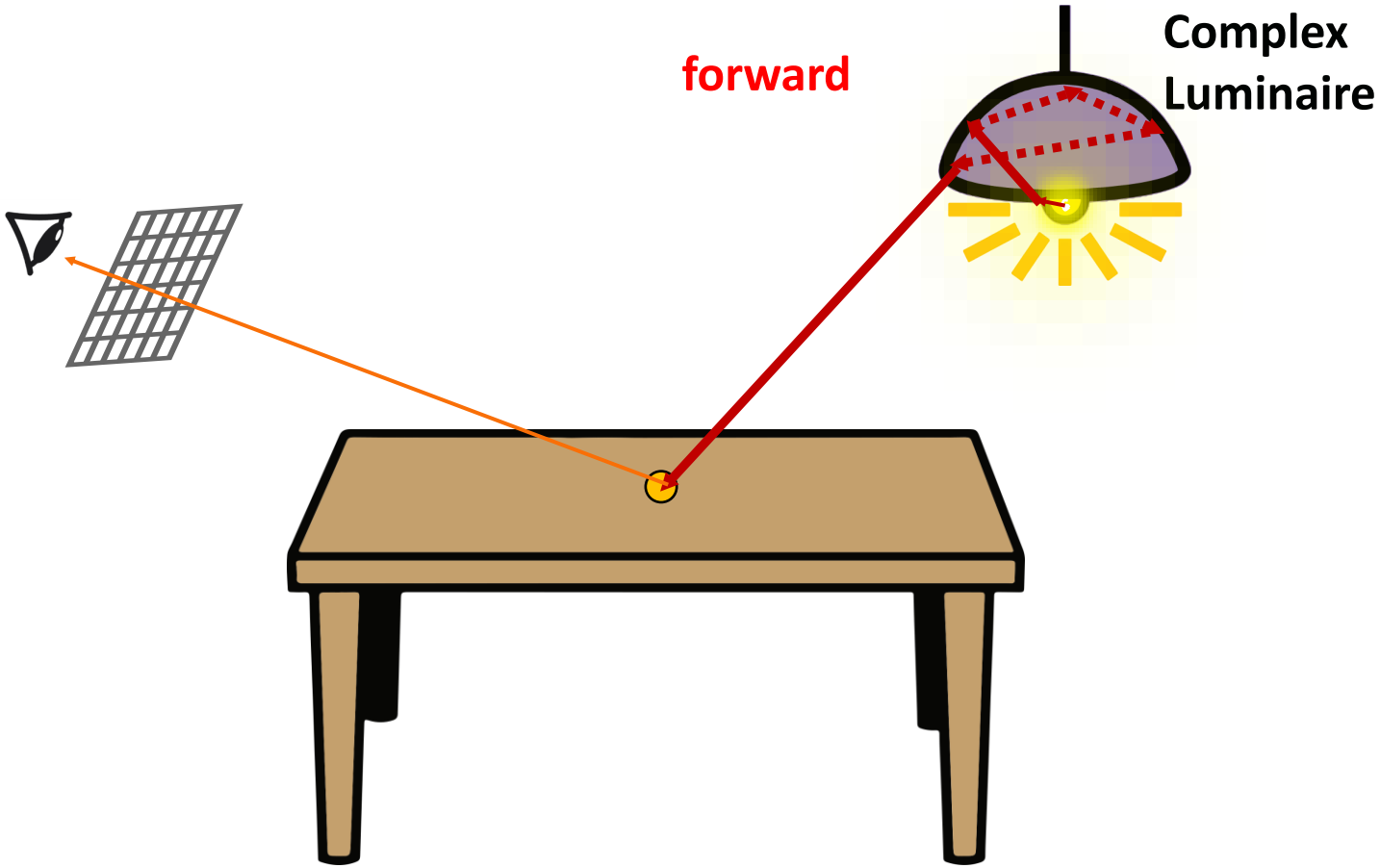
PROBLEMS

Complex geometries

Complex light transport



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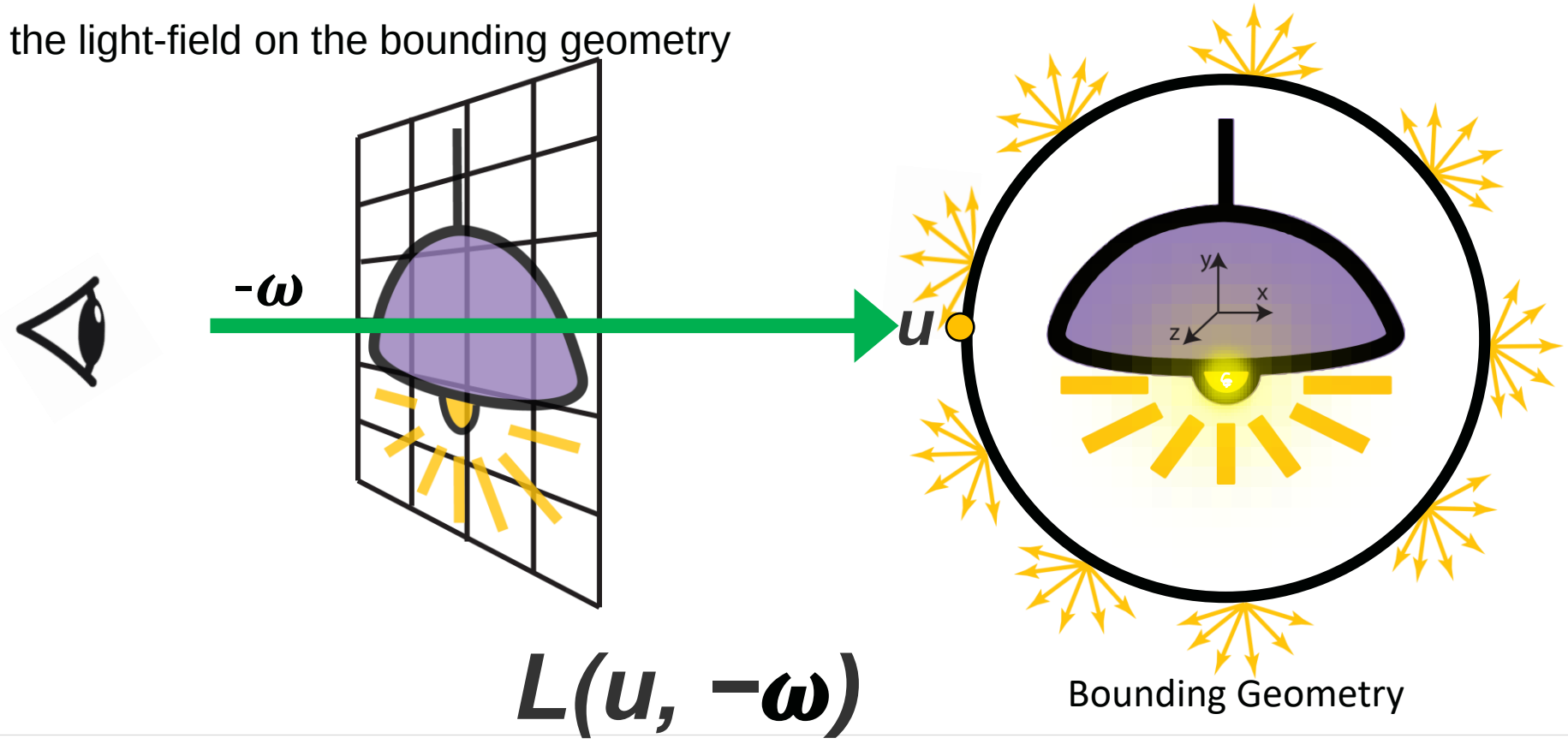
COMPLEX LUMINAIRE REPRESENTATION

Light-field (direction and position) simplify the complex light transport and geometry

Record the light-field on the bounding geometry



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LIGHT FIELD

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Record 4D position-direction information

[Chang et al. 2006]

256*256*256*256= 16GB in float

[Heidrich et al. 1998]
Canned light
implemented by Velázquez

Low resolution

Large storage

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NEURAL RADIANCE FIELDS

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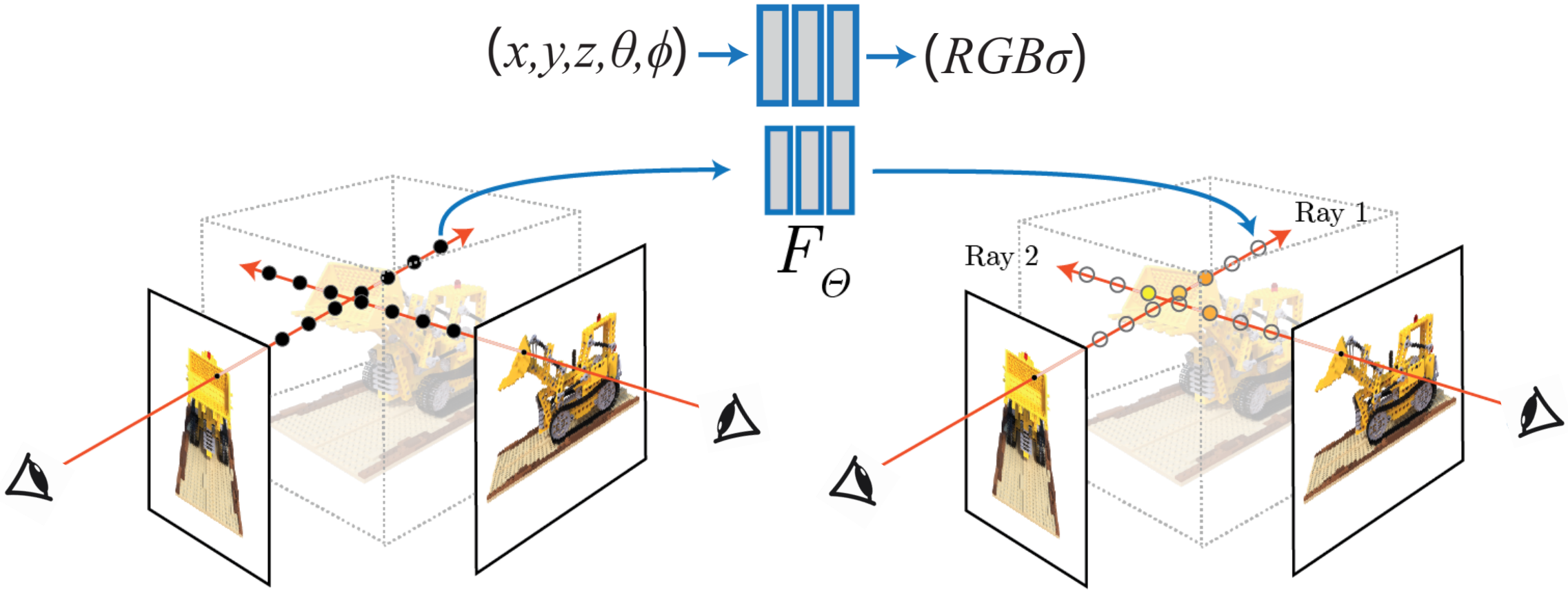
Nerf = Ray Marching + MLP



[Mildenhall et. al. 2020]

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NEURAL COMPLEX LUMINAIRE (OURS)
EVALUATION

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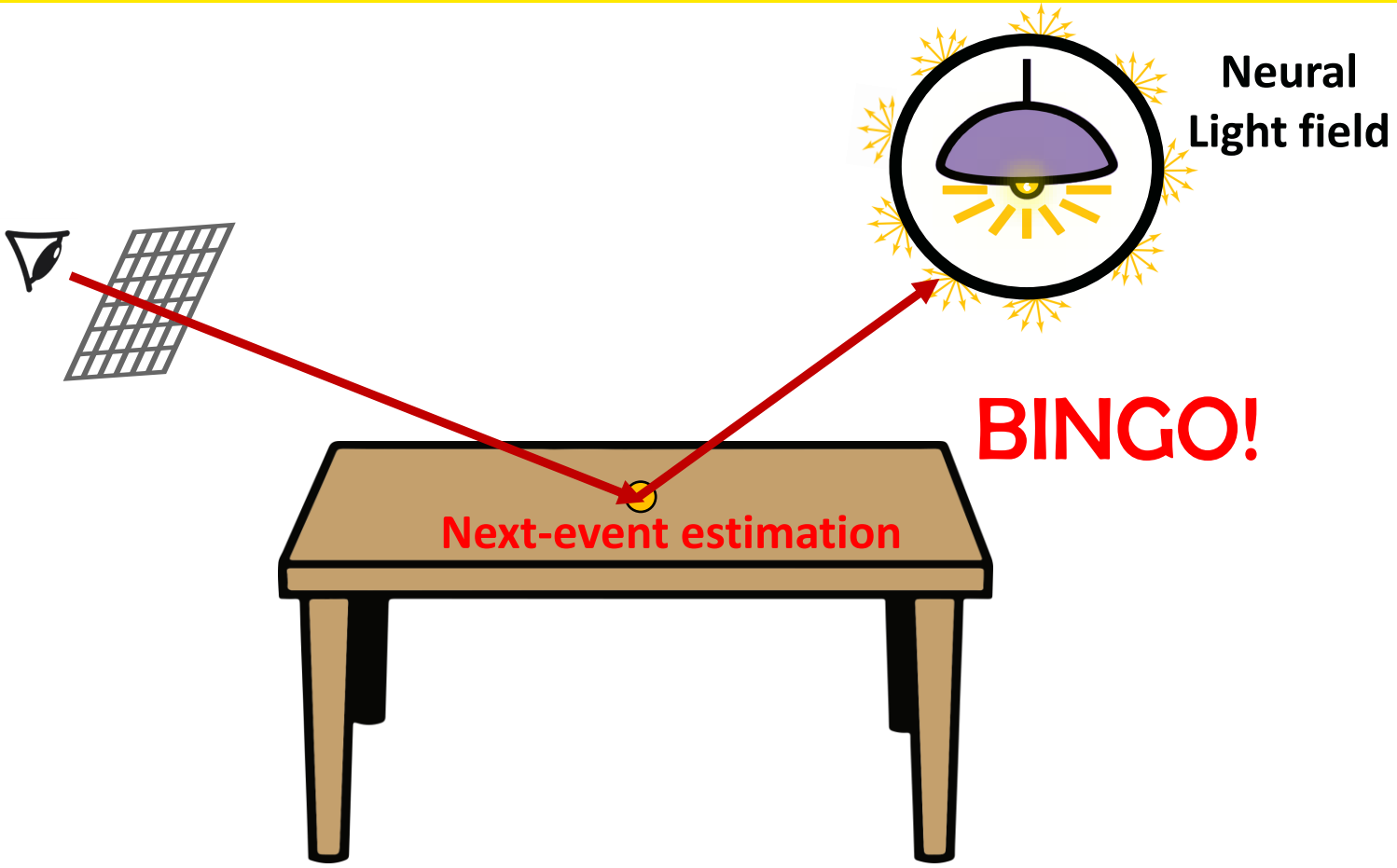
Complex geometries ✓

Complex light transport ✓



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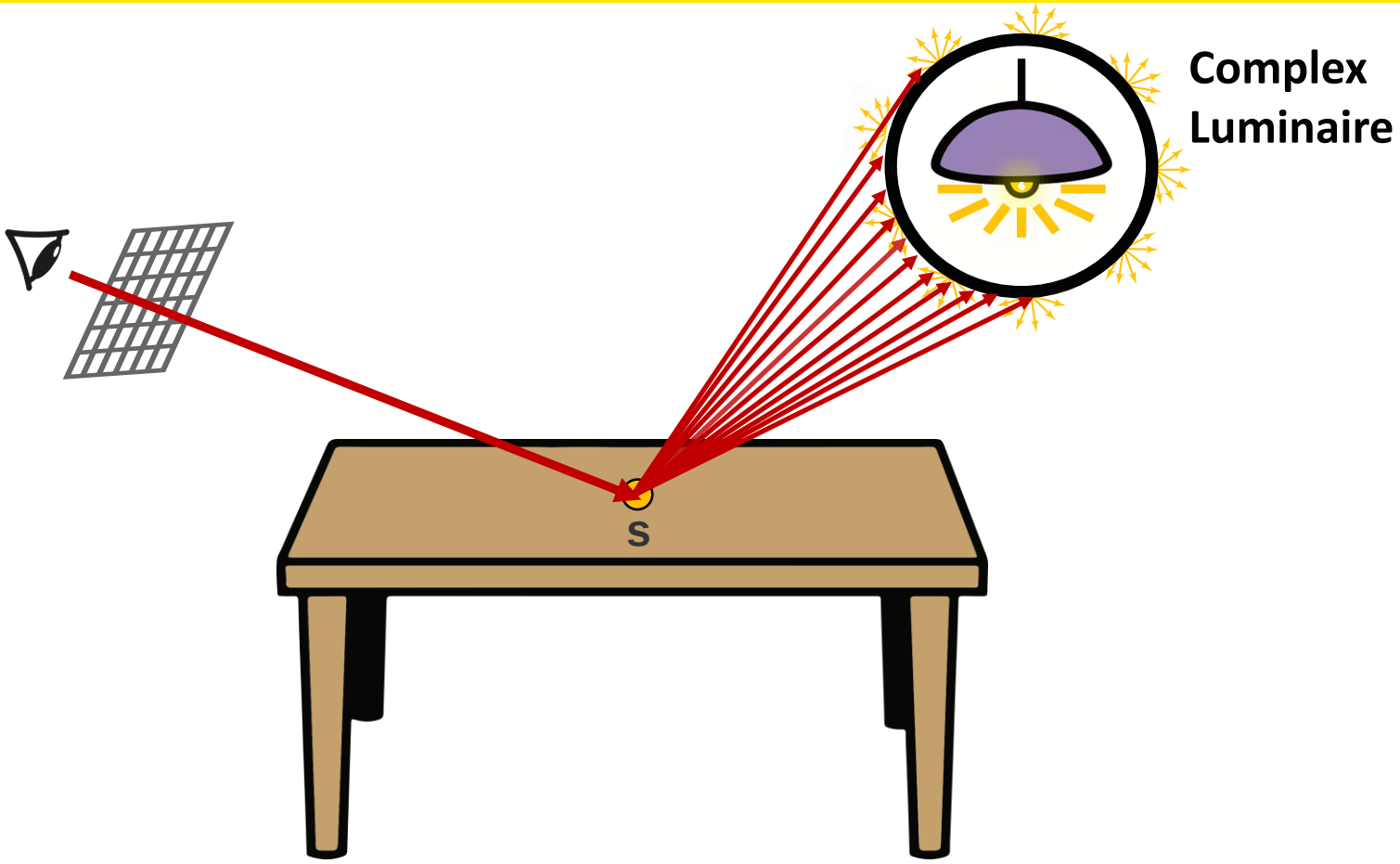
NEURAL COMPLEX LUMINAIRE (OURS)
SAMPLING

Importance sampling



Uniform sample: not efficient

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IMPORTANCE SAMPLING

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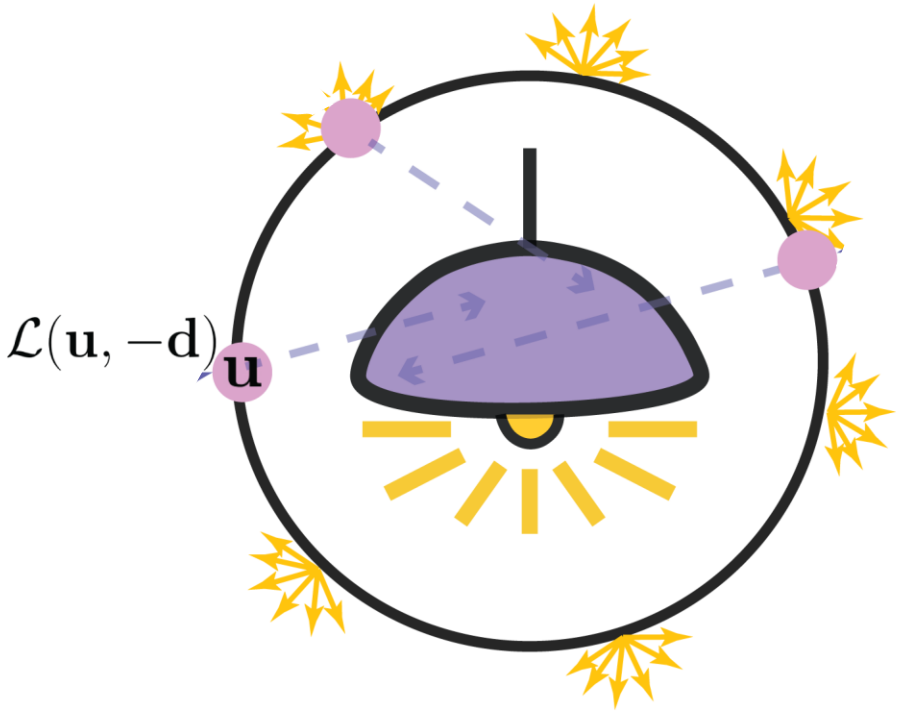
Importance sample at each shading point



Importance sampling network

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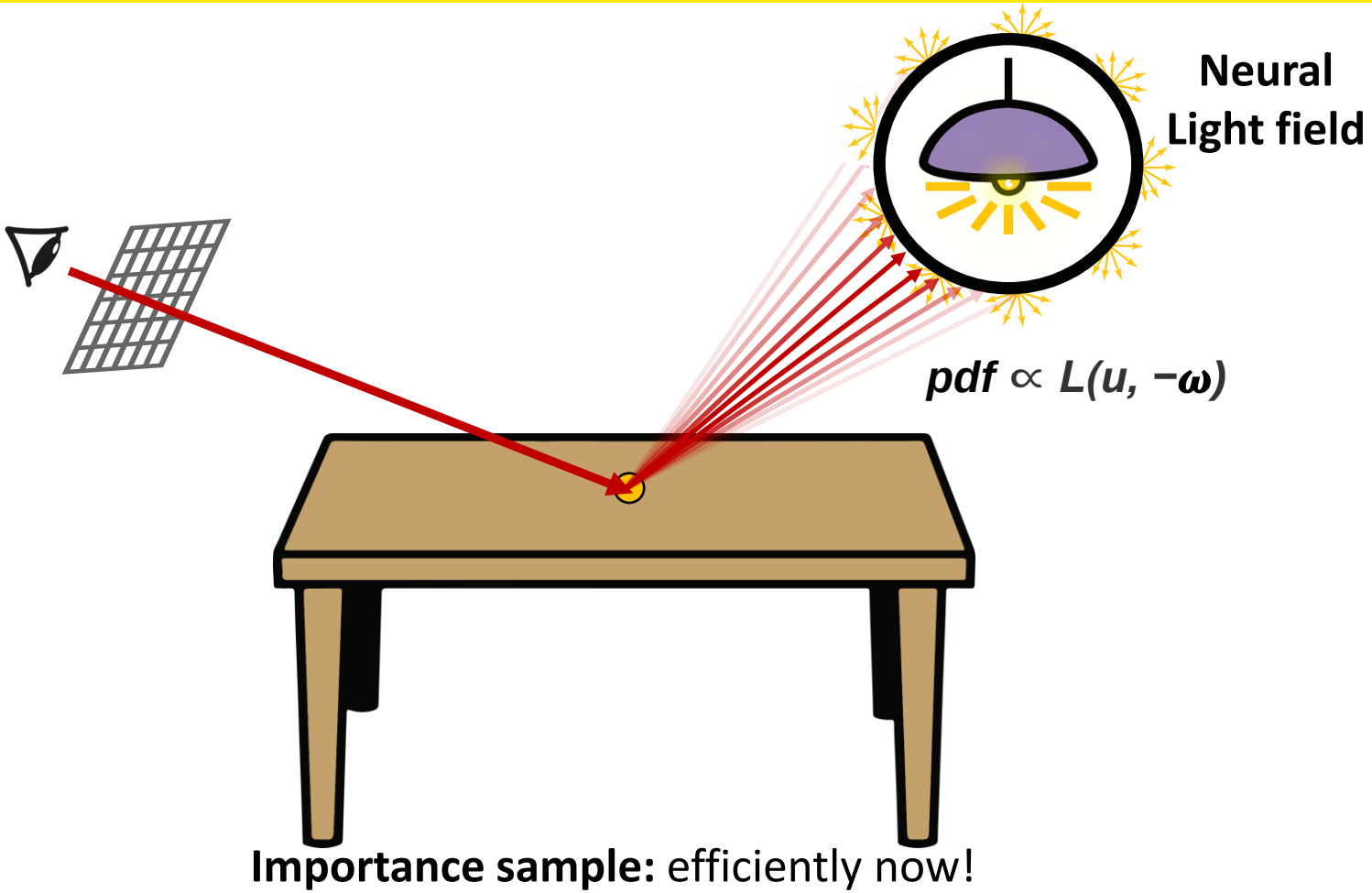
NEURAL COMPLEX LUMINAIRE (OURS)
SAMPLING

Importance sampling ✓



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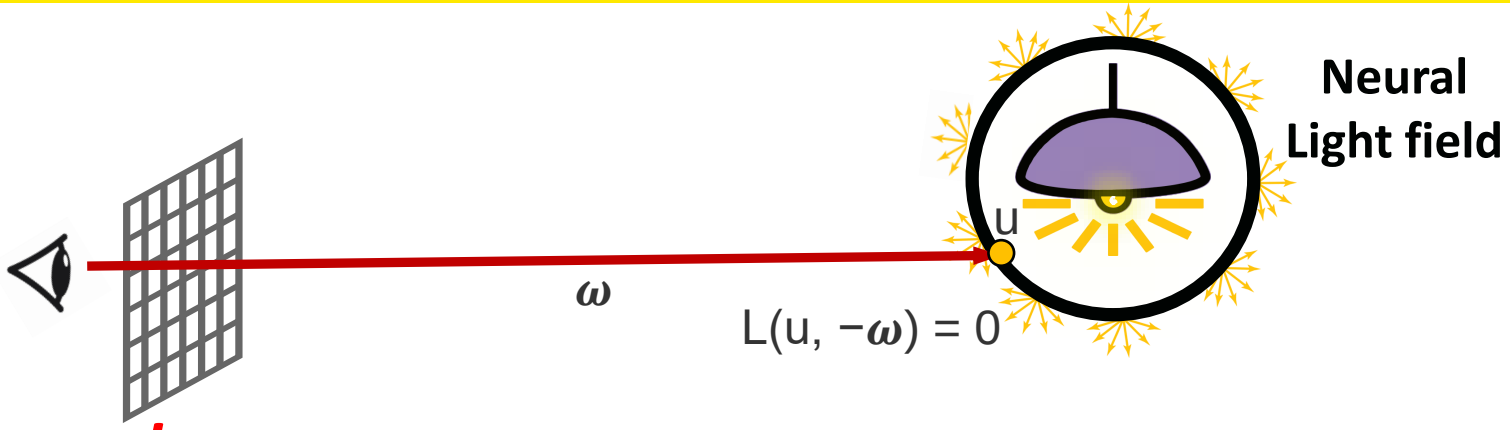
NEURAL COMPLEX LUMINAIRE (OURS)
BLENDING



Blend the luminaire and background

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COMPLEX LUMINAIRE TRANSPARENCY

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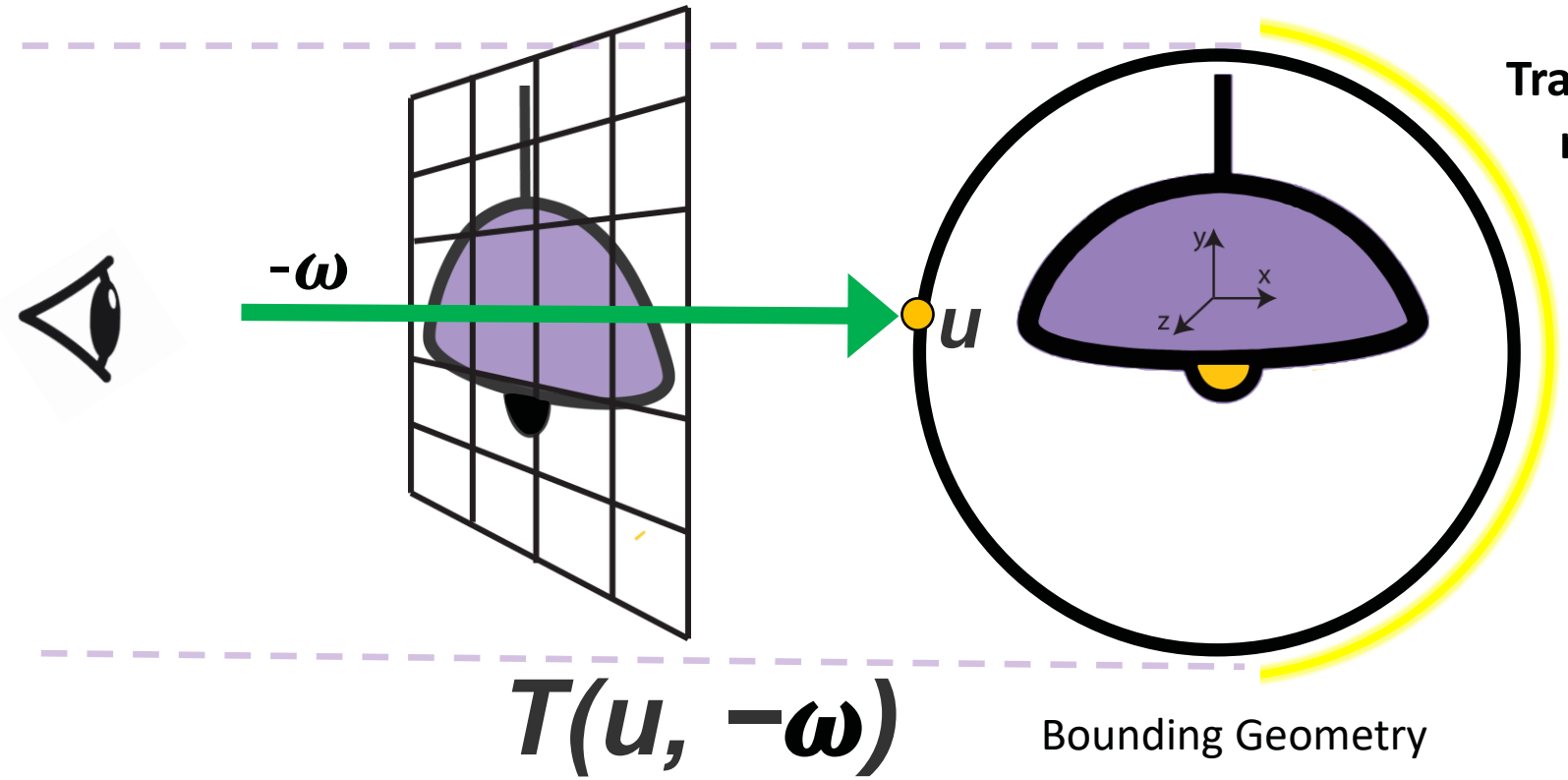
Same structure as the evaluation network

Transparency field



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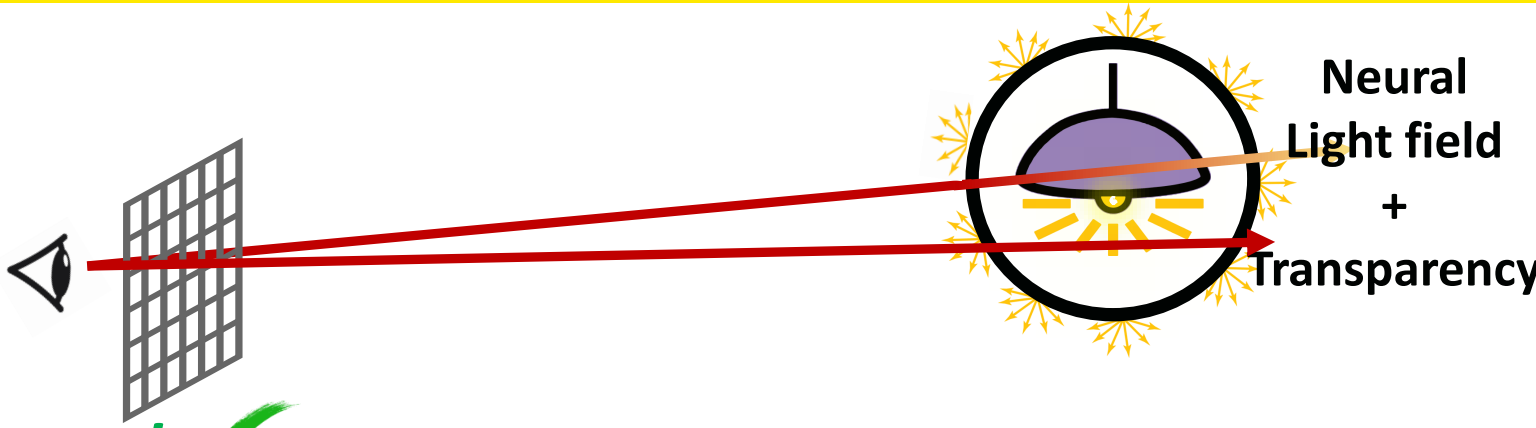
NEURAL COMPLEX LUMINAIRE (OURS)
BLENDING



Blend the luminaire and background ✓

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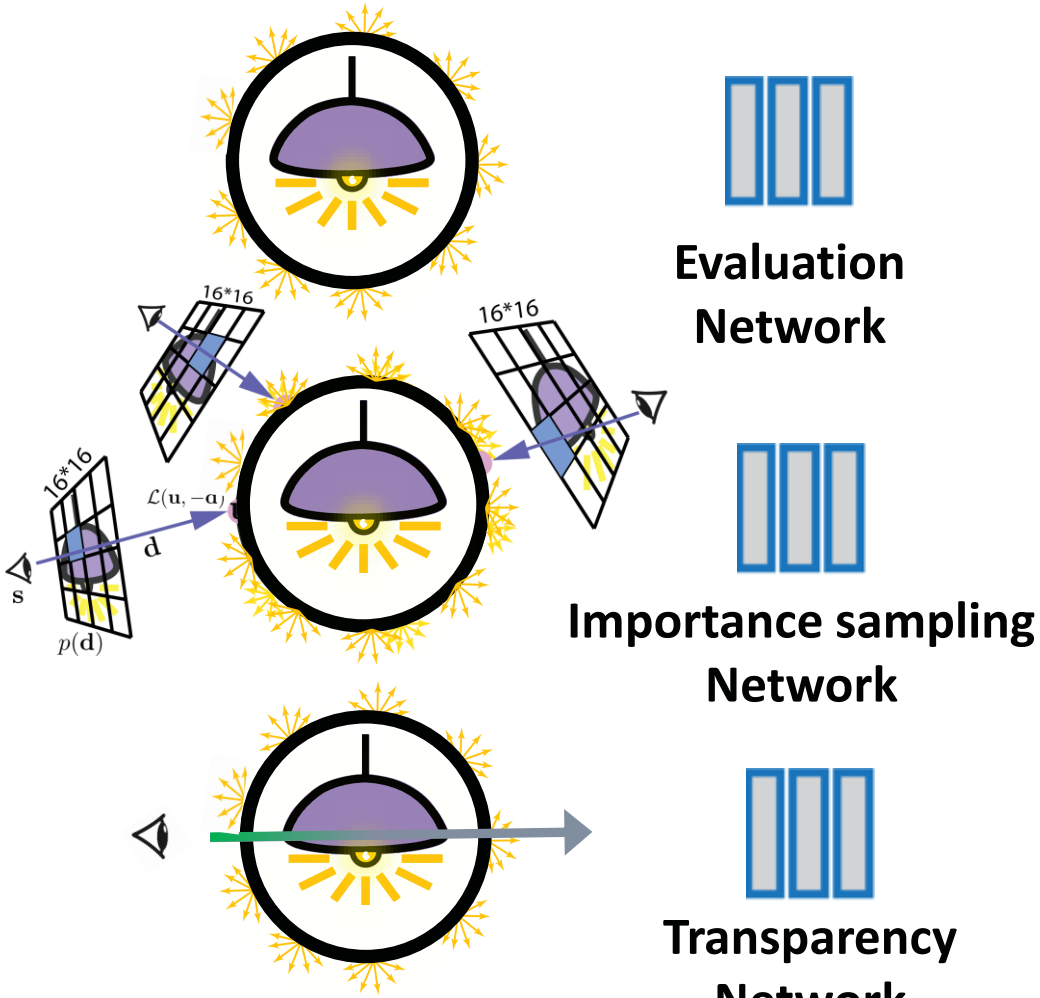
OUR METHOD



A neural method which represent complex luminaires as "black boxes"

- ***Evaluation***
- ***Sample & pdf***
- ***Blending***

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ANISOTROPIC POINT LIGHTS

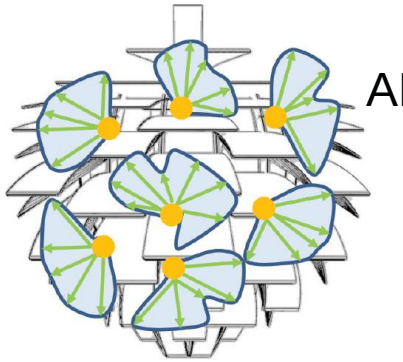
- **Two-pass rendering**
  Illumination Appearance
  Separately

Large storage

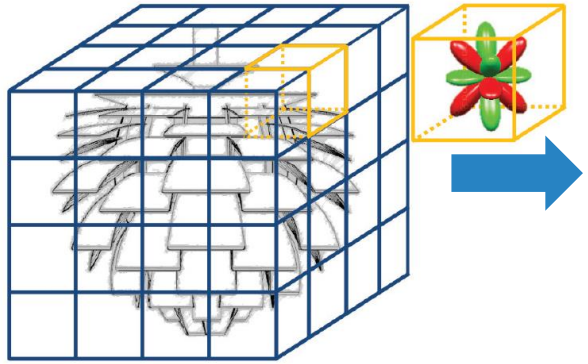
Can’t support MIS

Original geometry

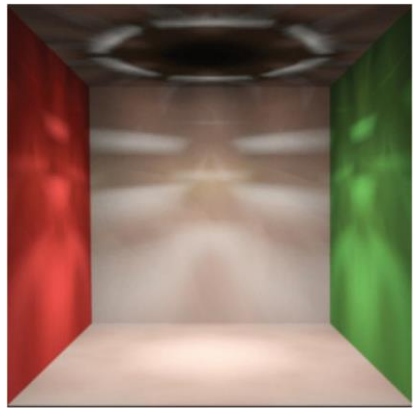
Precompute

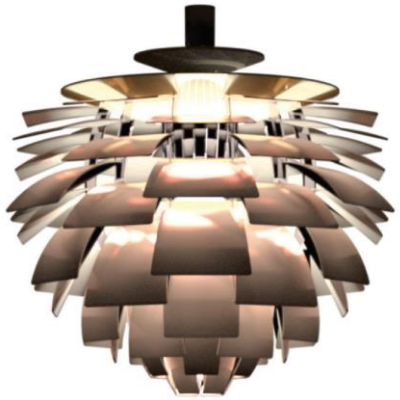


APLs



Rendering





Final

[Velázquez et. al. 2015]

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OUR CONTRIBUTION

- A compact representation
- Standard rendering system integration
- Efficient and accurate rendering
- No real geometry

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COMPARISON TO PREVIOUS WORKS

Method	Importance Sampling	Storage	Original geometry	Speed
Light field	No	Very Large	No	Slow
Nerf	No	Small	No	Slow
APL	No	Large	Yes	Fast
Ours	Yes	Small	No	Very Fast

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OUR APPROACH

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OVERVIEW

? *Illumination*

? *Appearance*

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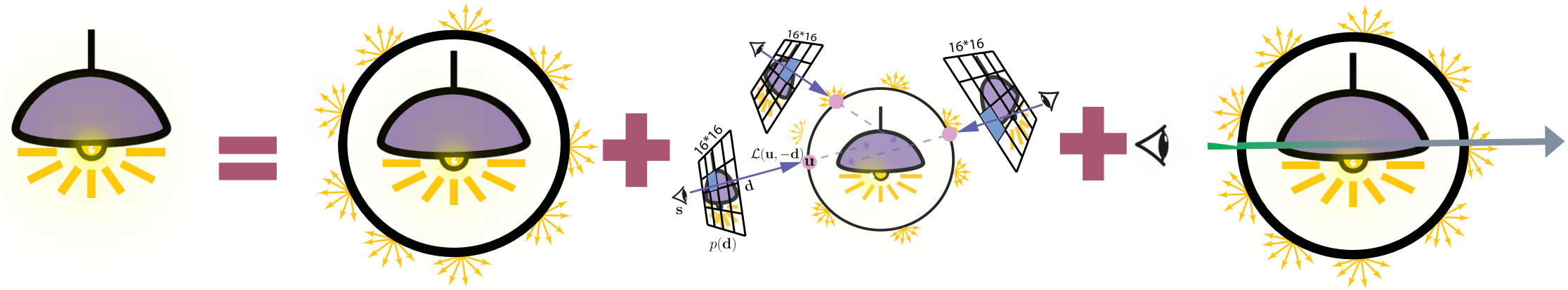

Complex luminaire *Eval()* *Sample() & Pdf()* *Alpha()*

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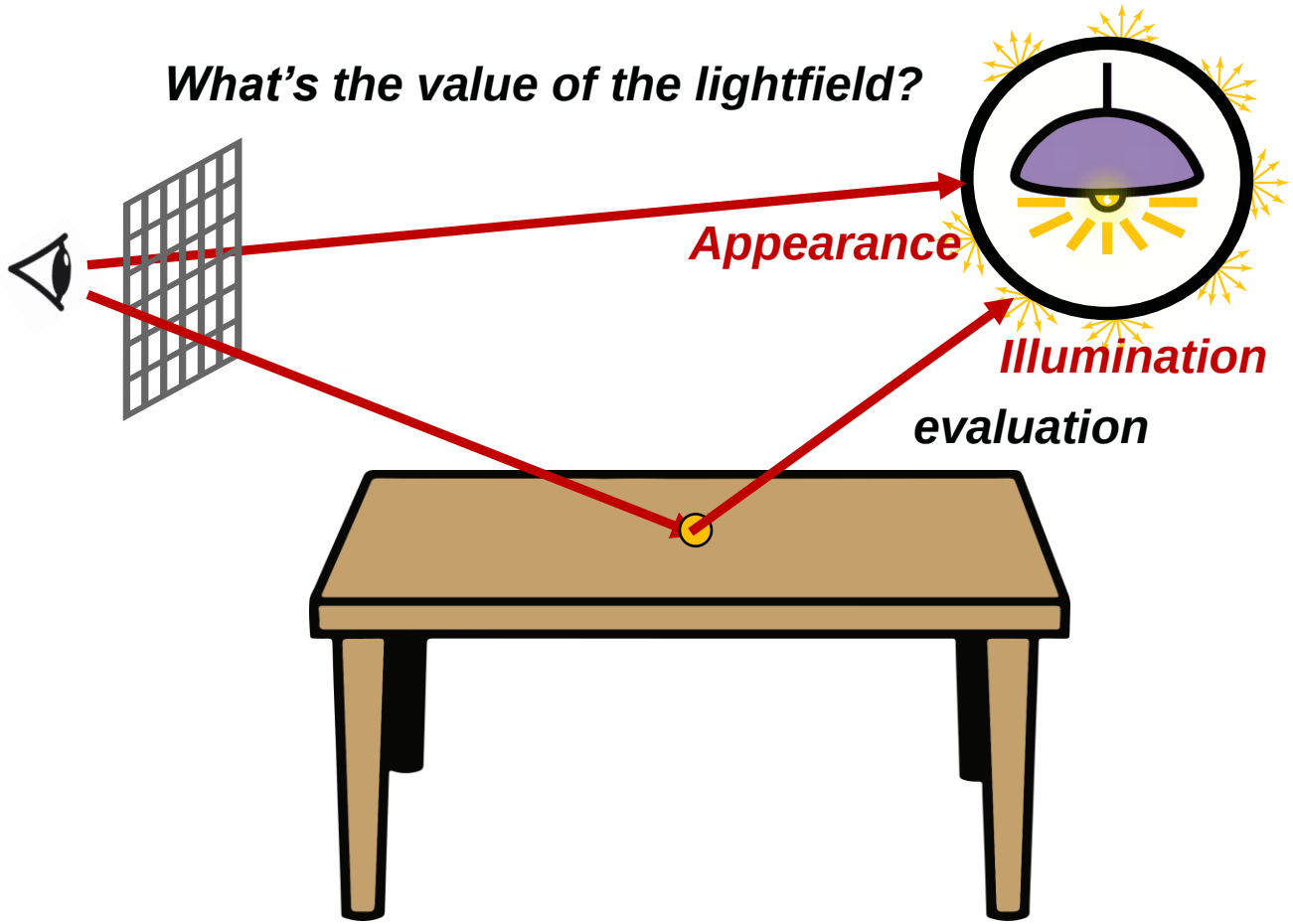
COMPLEX LUMINAIRE EVALUATION



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COMPLEX LUMINAIRE REPRESENTATION

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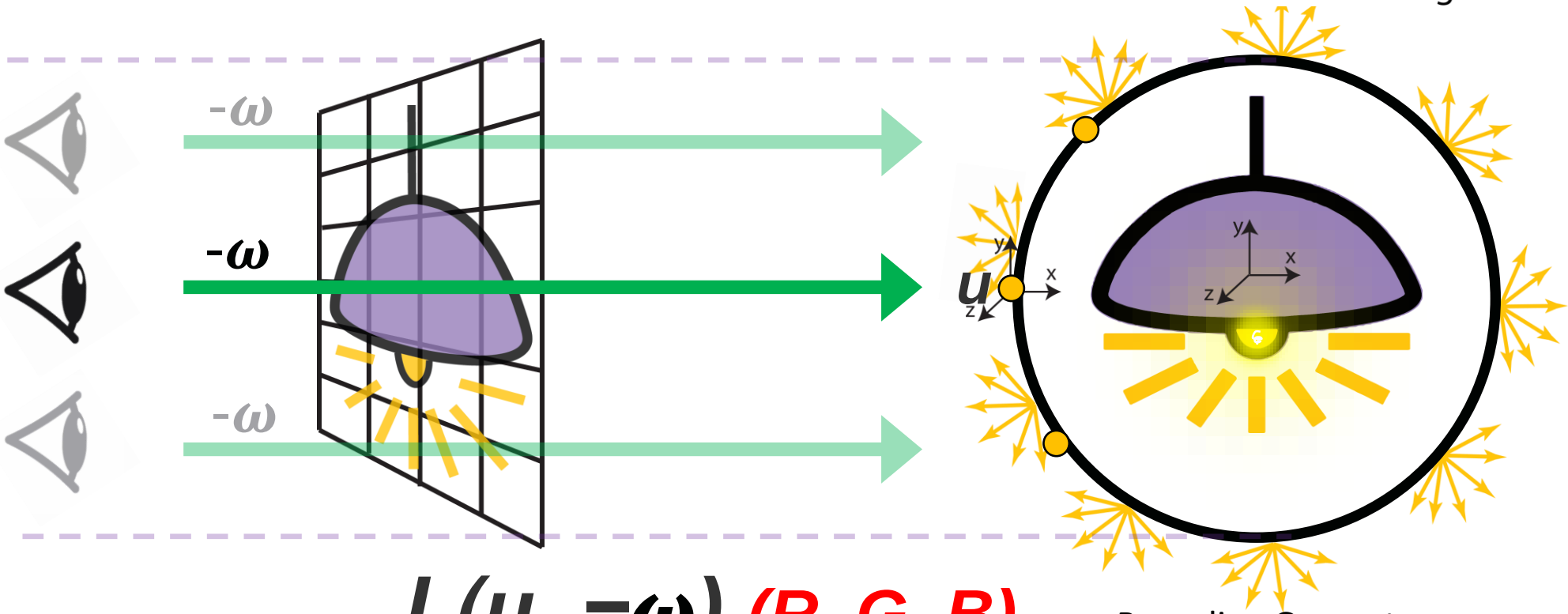
Light-field

Note: calculation in black background



$L(u, -\omega)$ (R, G, B)

Bounding Geometry

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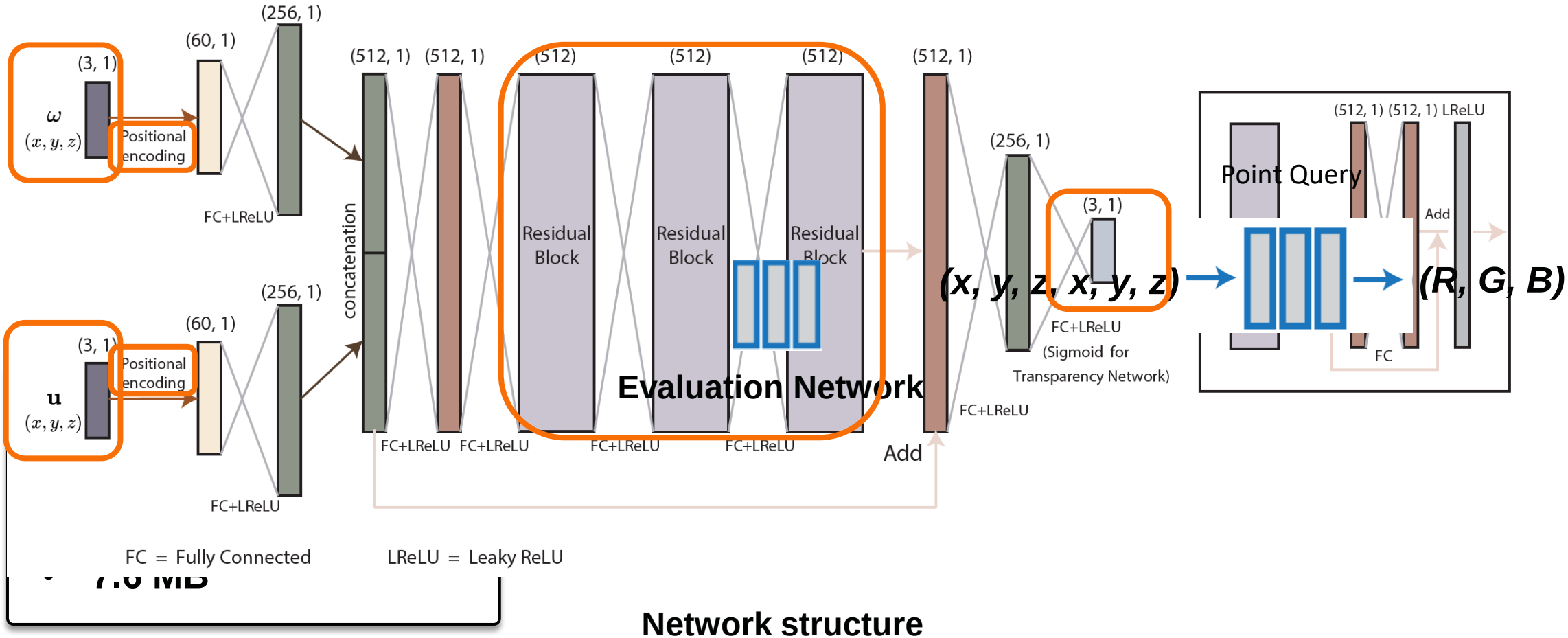
REPRESENTATION
EVALUATION NETWORK



Network structure

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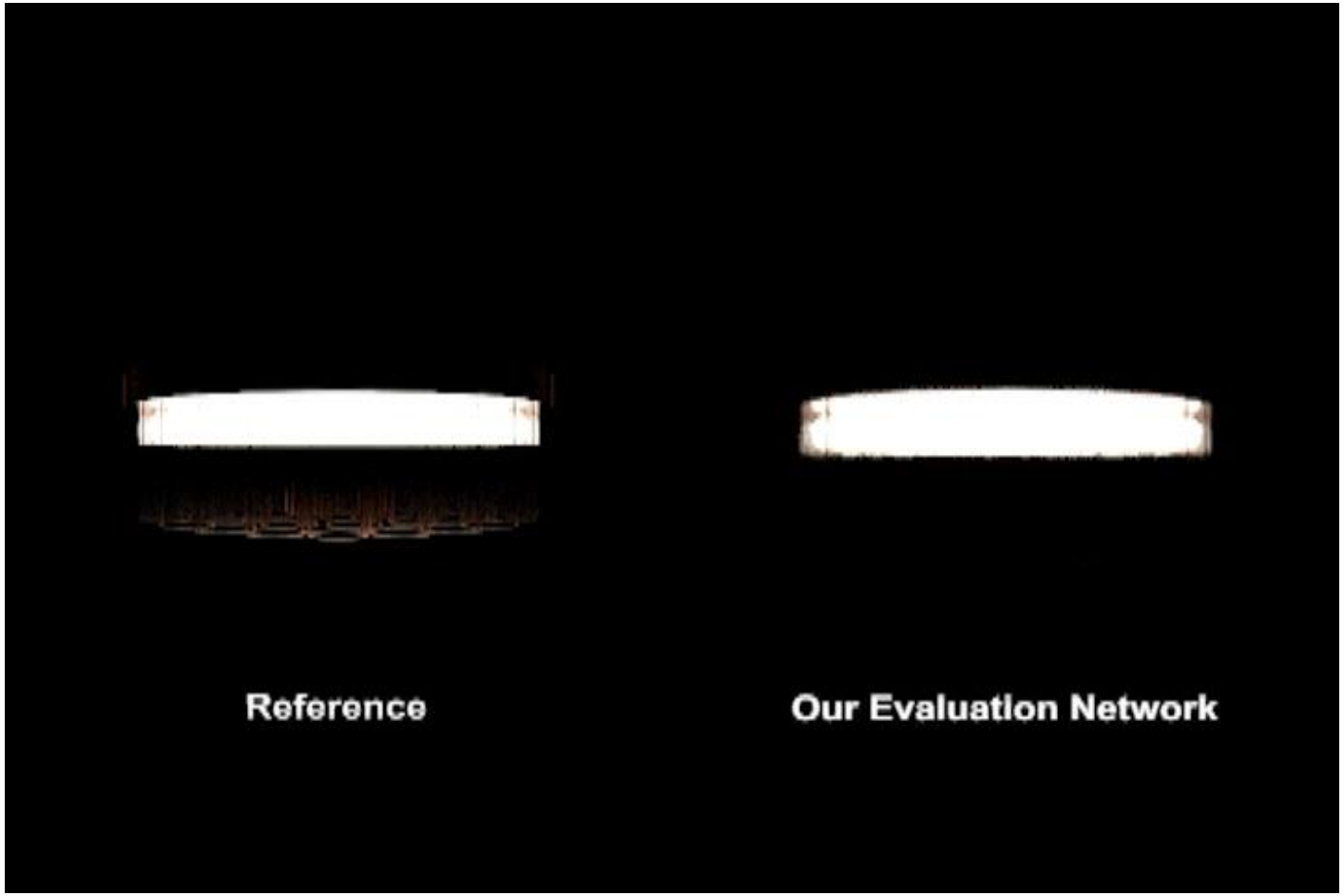
EVALUATION NETWORK



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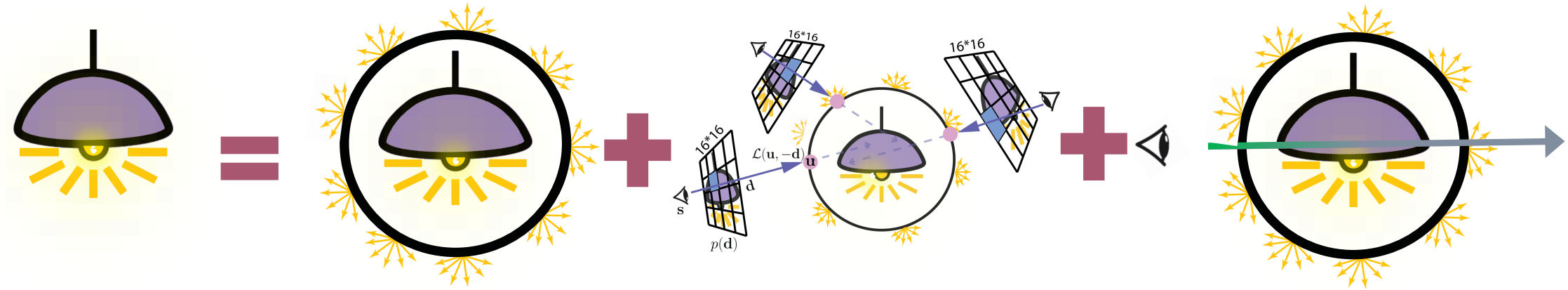
OVERVIEW

? *illumination*

? *Appearance*



Complex luminaire = ***Eval()*** + ***Sample() & Pdf()*** + ***Alpha()***

Evaluation network

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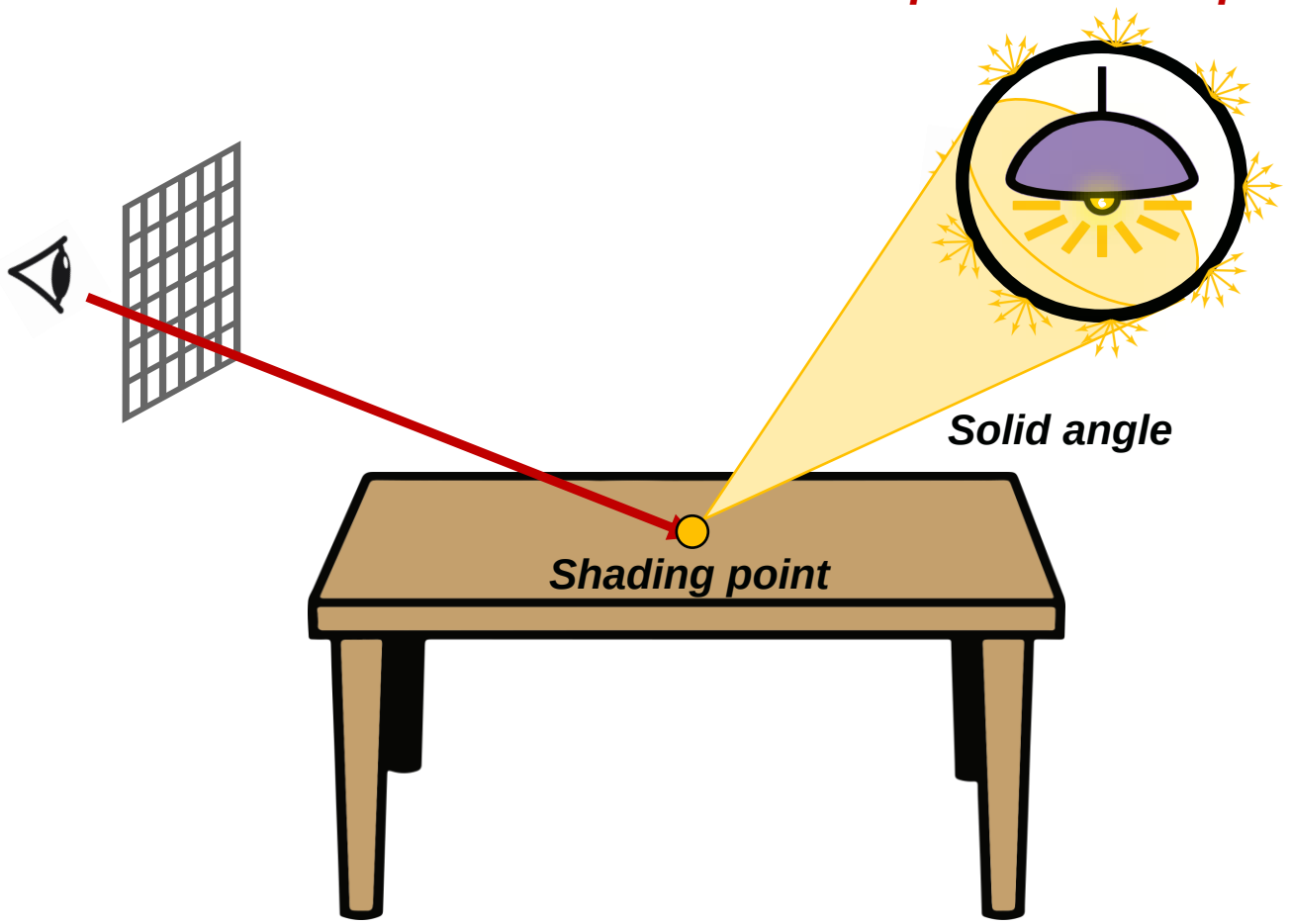
COMPLEX LUMINAIRE EVALUATION

How to importance sample light?

The shape of light we see?
Sample and pdf?



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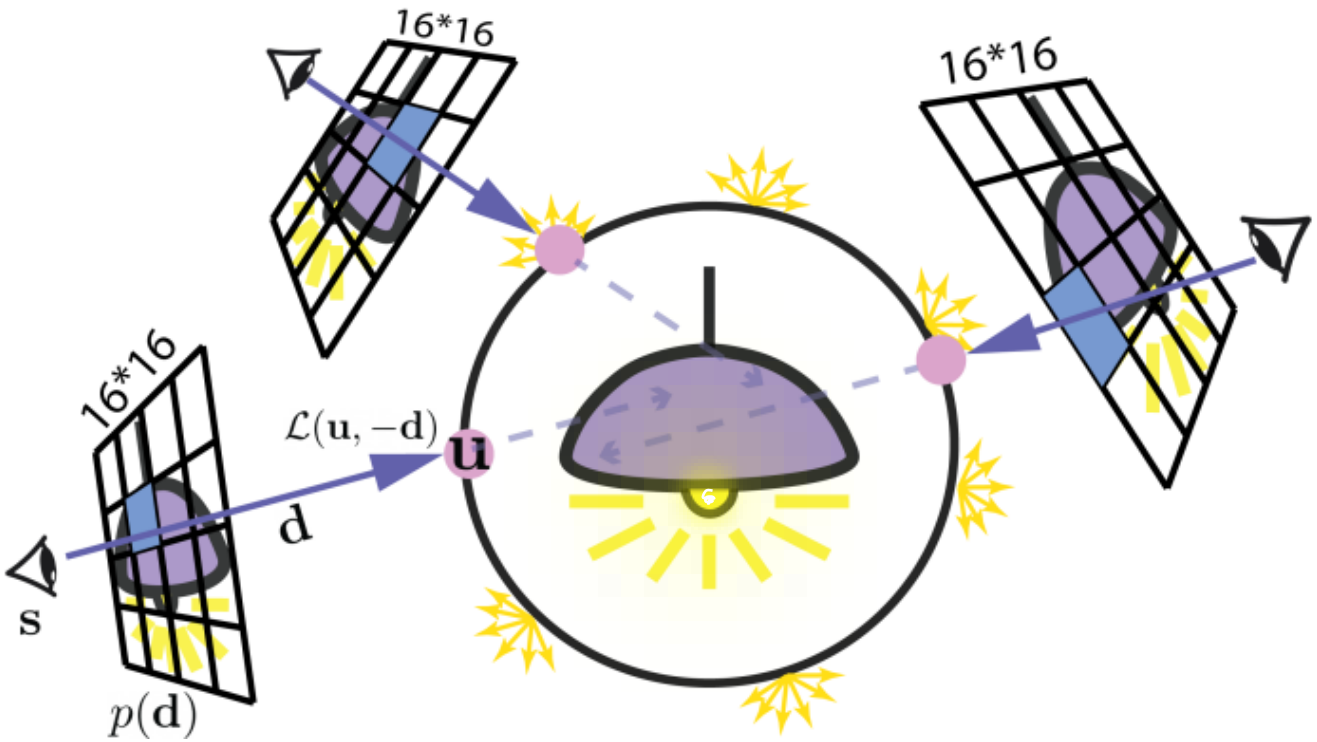
IMPORTANCE SAMPLING



16*16*L(u, d) 16*16* (R, G, B)

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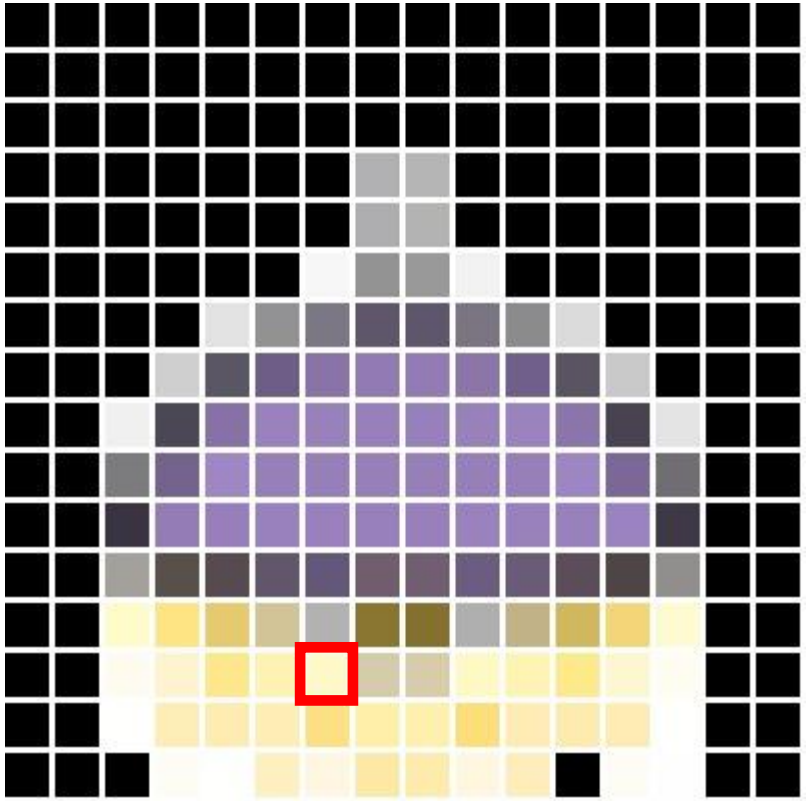
IMPORTANCE SAMPLING



$$pdf \propto L(u, d)$$

$$Sampling\ weight = L(u, d) / pdf(\mathbf{d})$$

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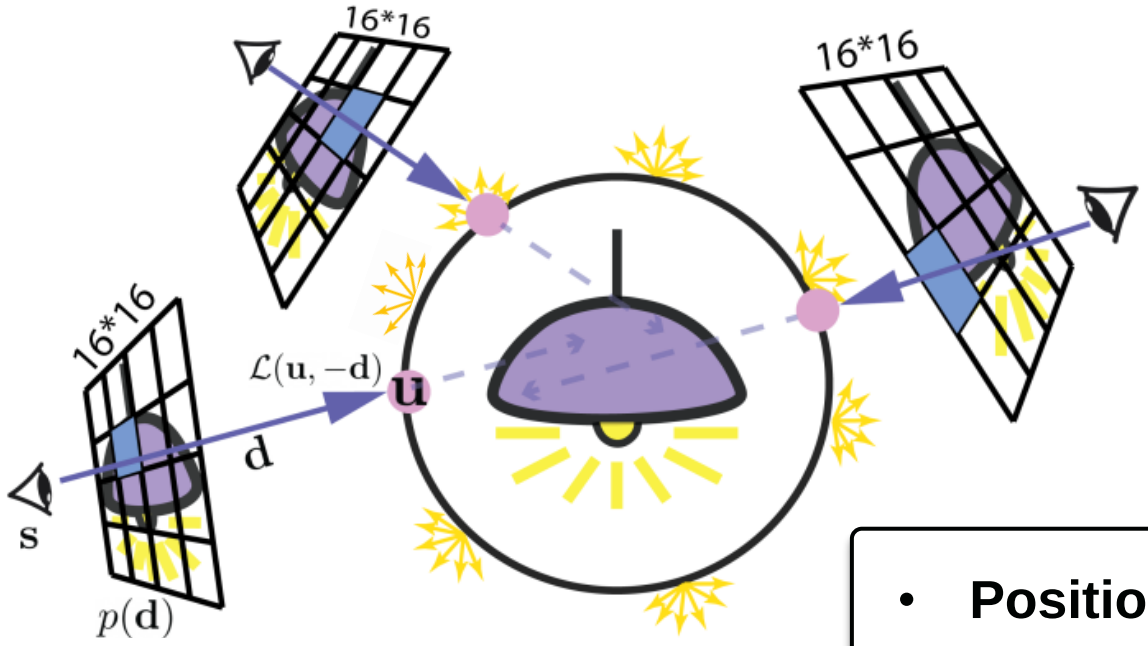
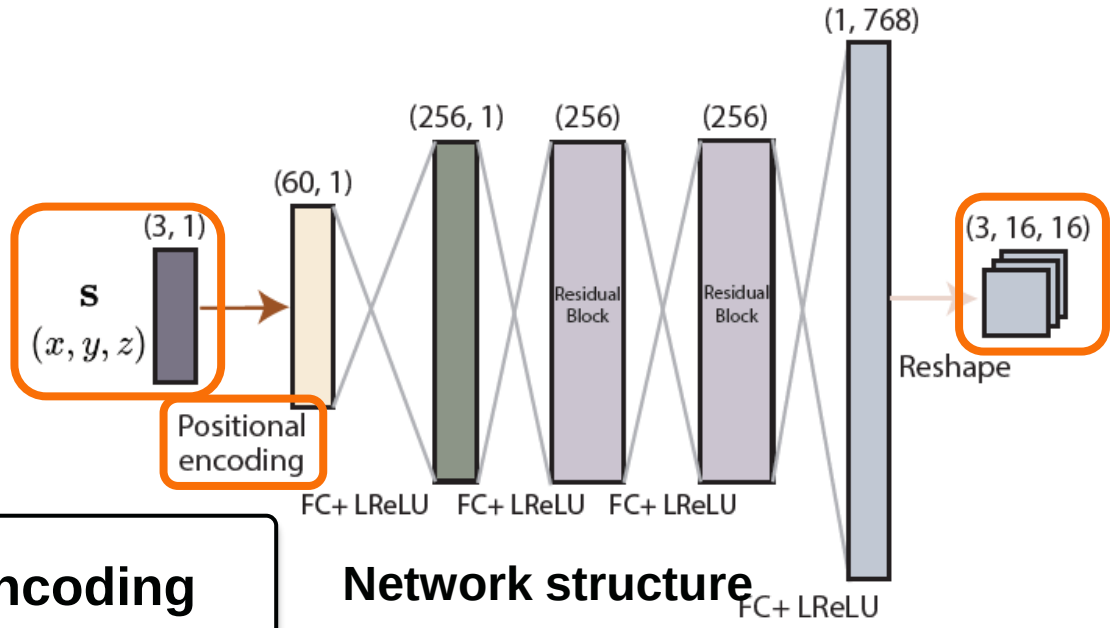
IMPORTANCE SAMPLING NETWORK





Network structure

- Positional encoding
- No epoch
- 12h training
- 1.8 MB
- Preserve the energy

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IMPORTANCE SAMPLING NETWORK

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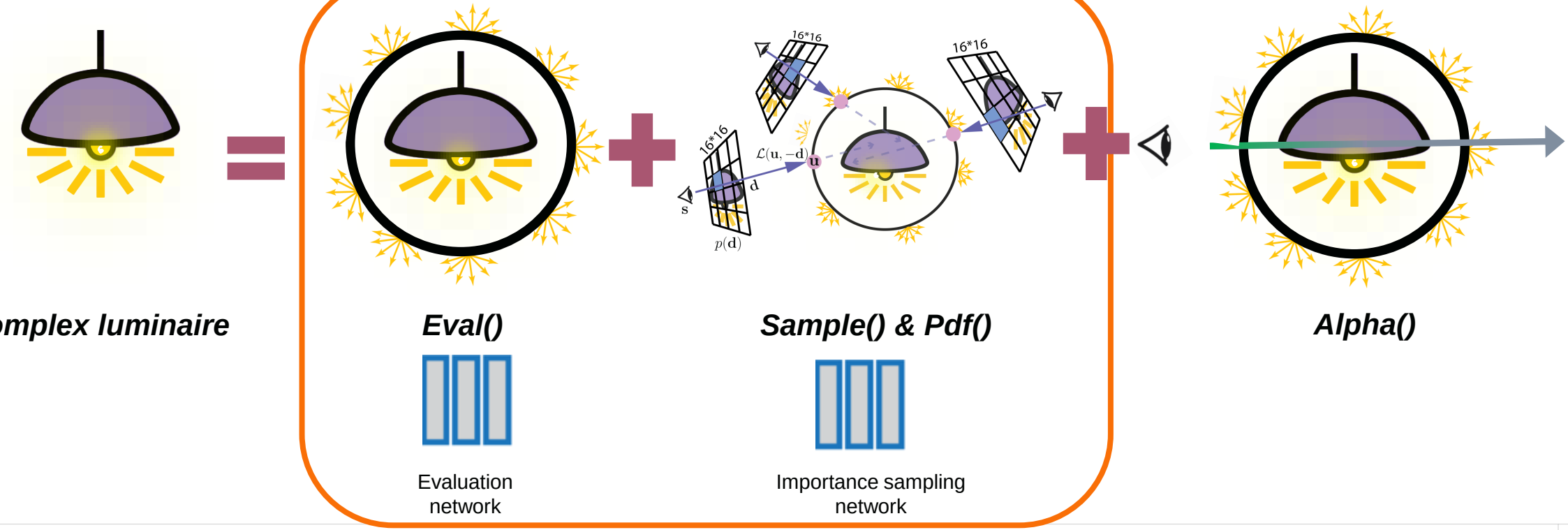
Illumination



Complex luminaire

Eval()

Evaluation network

Sample() & Pdf()

Importance sampling network

Alpha()

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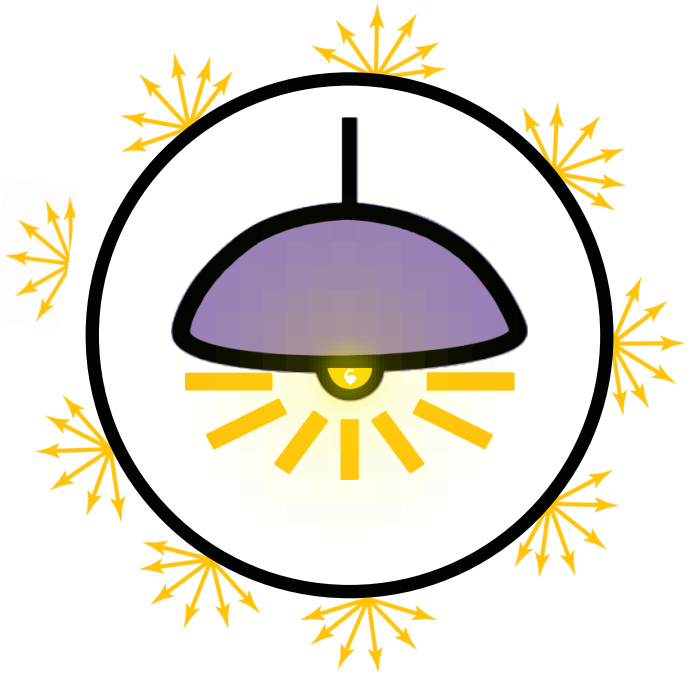
RENDERING-TRANSPARENCY

What we need

Evaluation network

What we have



Evaluation Network

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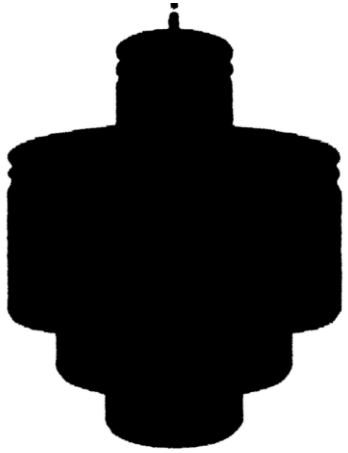
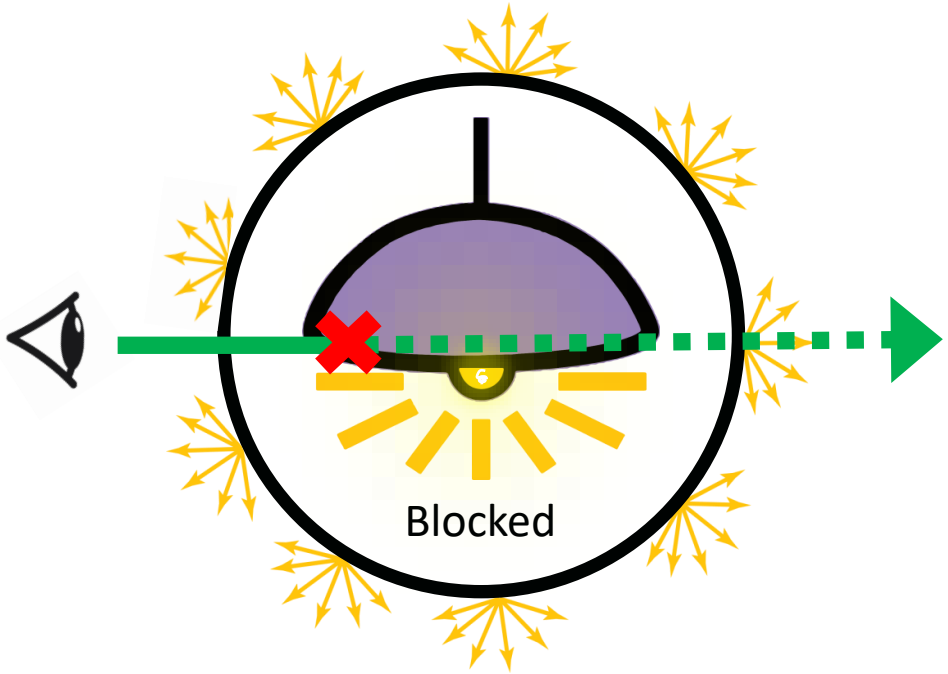
RENDERING-TRANSPARENCY

Binary mask



What we need

Dimmer



Evaluation Network+ Binary mask

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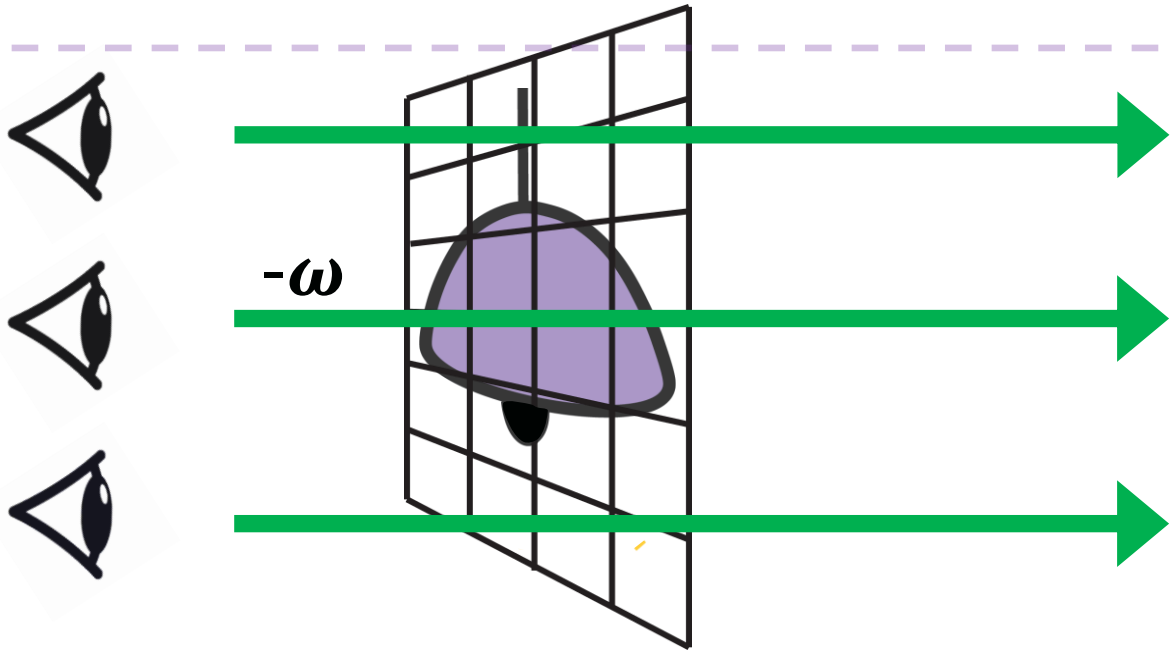
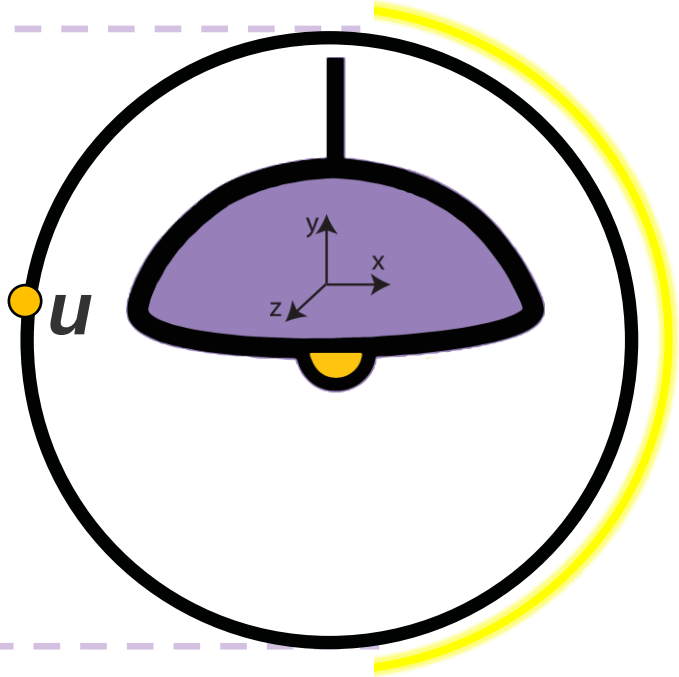
COMPLEX LUMINAIRE REPRESENTATION

Network structure is as same as the evaluation network

Transparency field





Transparency network

$T(u, -\omega)$

Bounding Geometry

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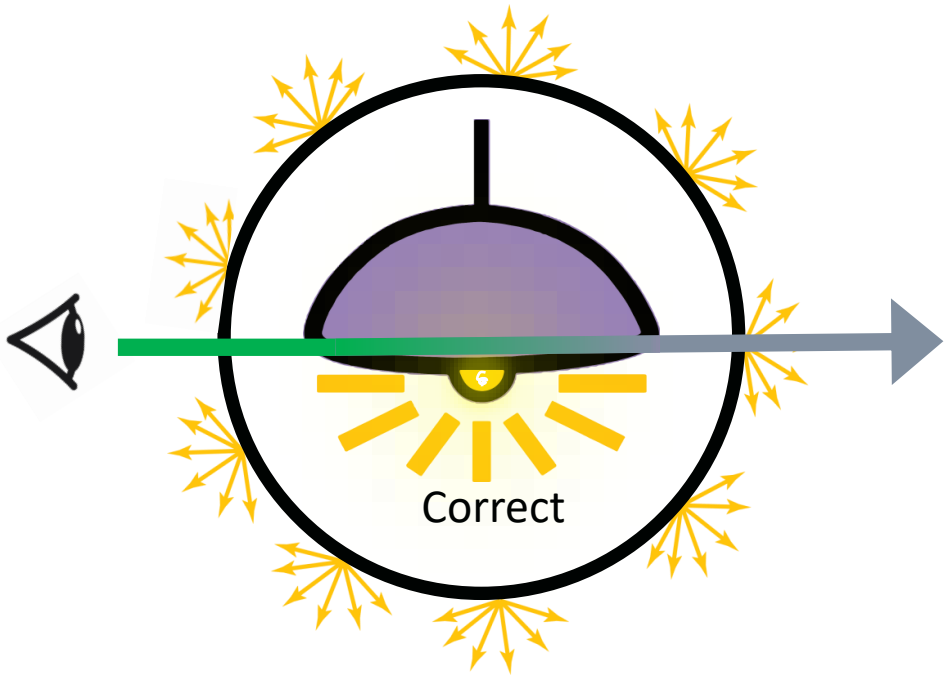
RENDERING-TRANSPARENCY

Transparency mask

What we need

Better! But the metal is black



Evaluation Network +Transparency mask

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RENDERING-TRANSPARENCY

What we need

Add metal geometry (very simple)

What we finally get

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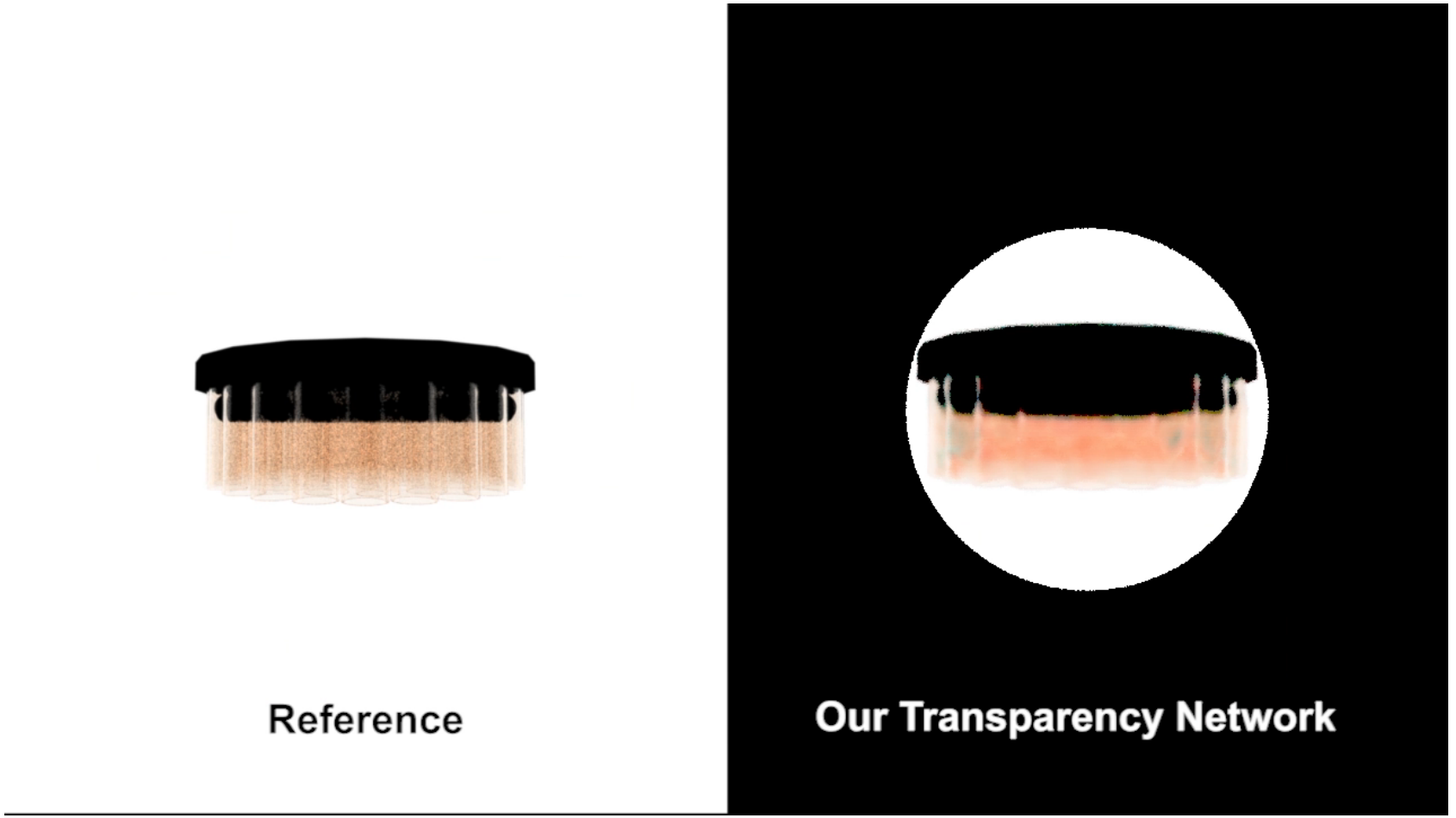
TRANSPARENCY NETWORK



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OVERVIEW

✔ *Illumination*

✔ *Appearance*

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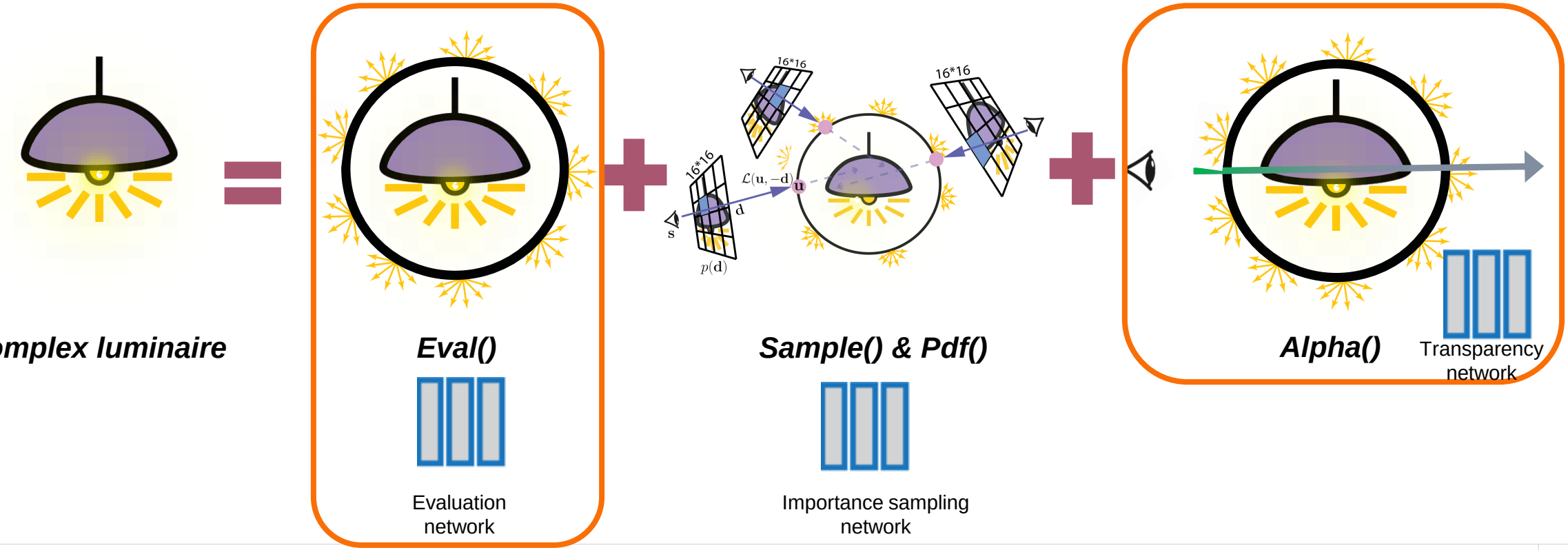
Appearance



Complex luminaire

Eval()

Evaluation network

Sample() & Pdf()

Importance sampling network

Alpha()

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RESULTS

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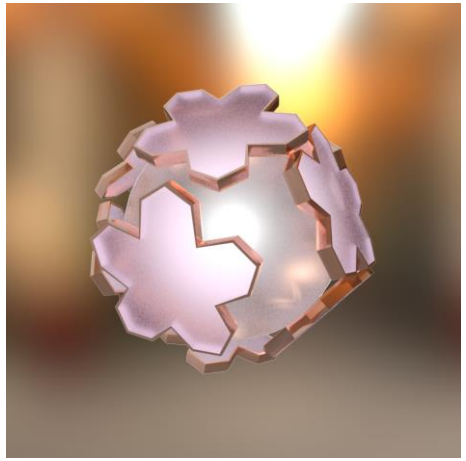
TYPICAL COMPLEX LUMINAIRES



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CAUSTIC PATHS

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SPECULAR SURFACE

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COMPLEX LIGHT TRANSFER

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SHARP PATTERN

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COMPLEX TIGHT BOUNDING

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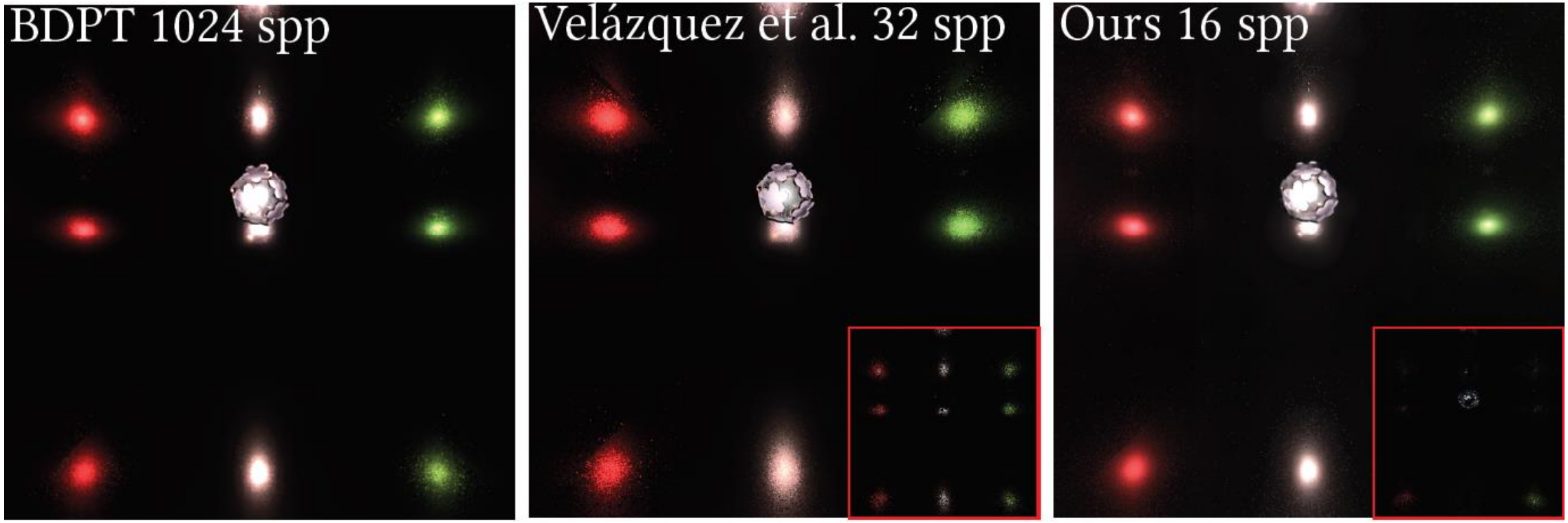
CORRECTNESS OF EVALUATION



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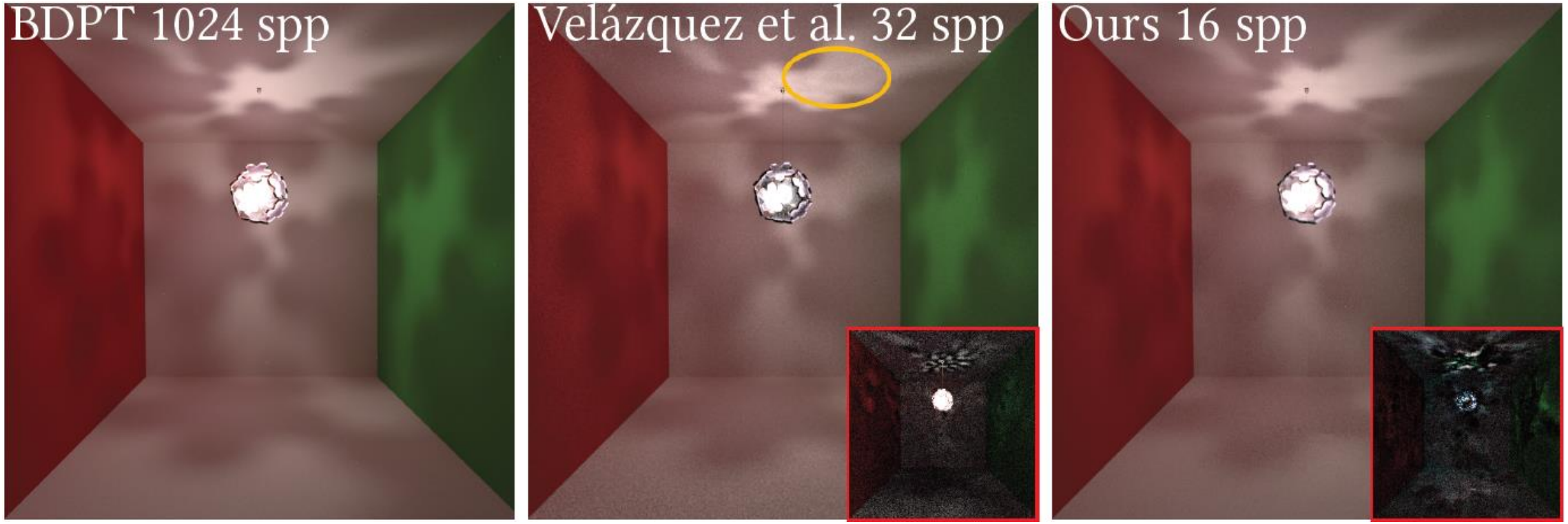
CORRECTNESS OF IMPORTANCE SAMPLING



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DISCUSSIONS

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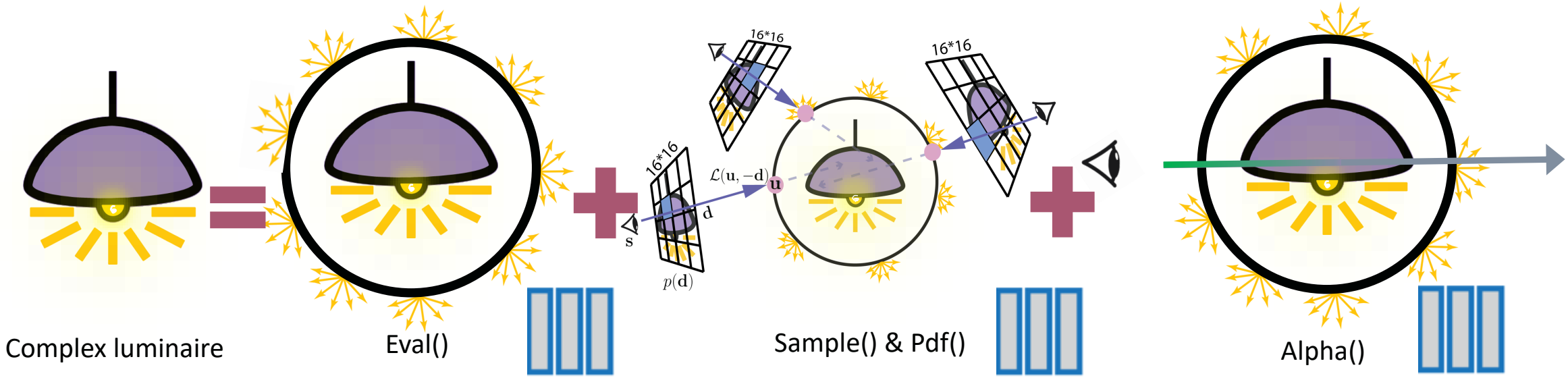
CONCLUSION



- ✓ Importance Sampling
- ✓ Accurately Efficiently
- ✓ Stable Storage

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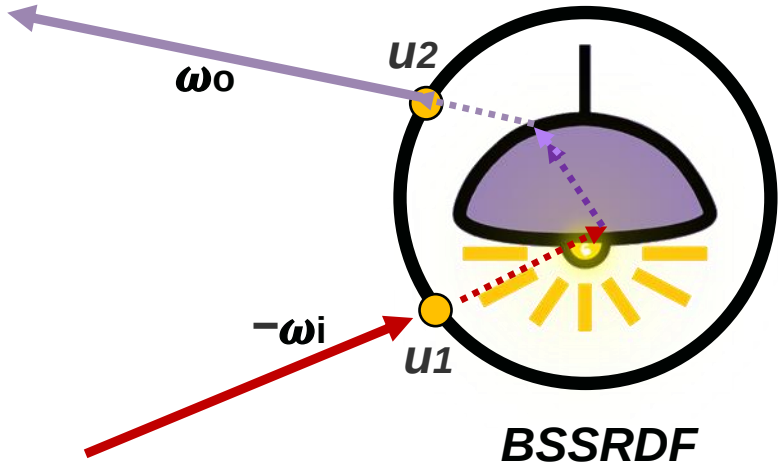
- ***Can't capture the external light bounces reflected from the scene***



BSSRDF

Can't capture the light itself

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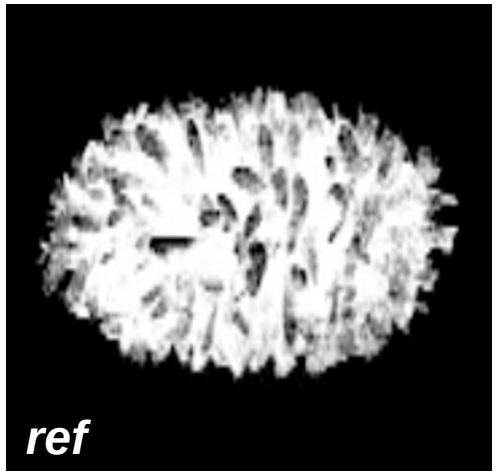
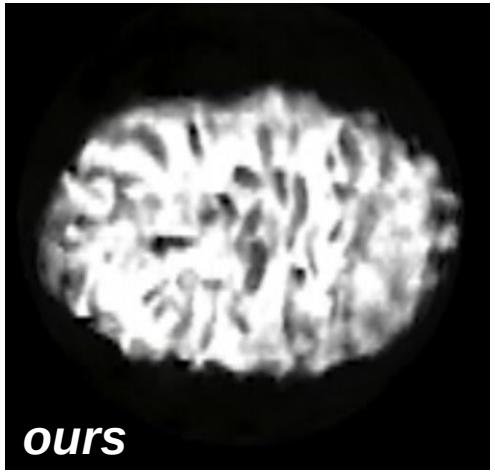
LIMITATIONS

- ***Blurring in the evaluation***





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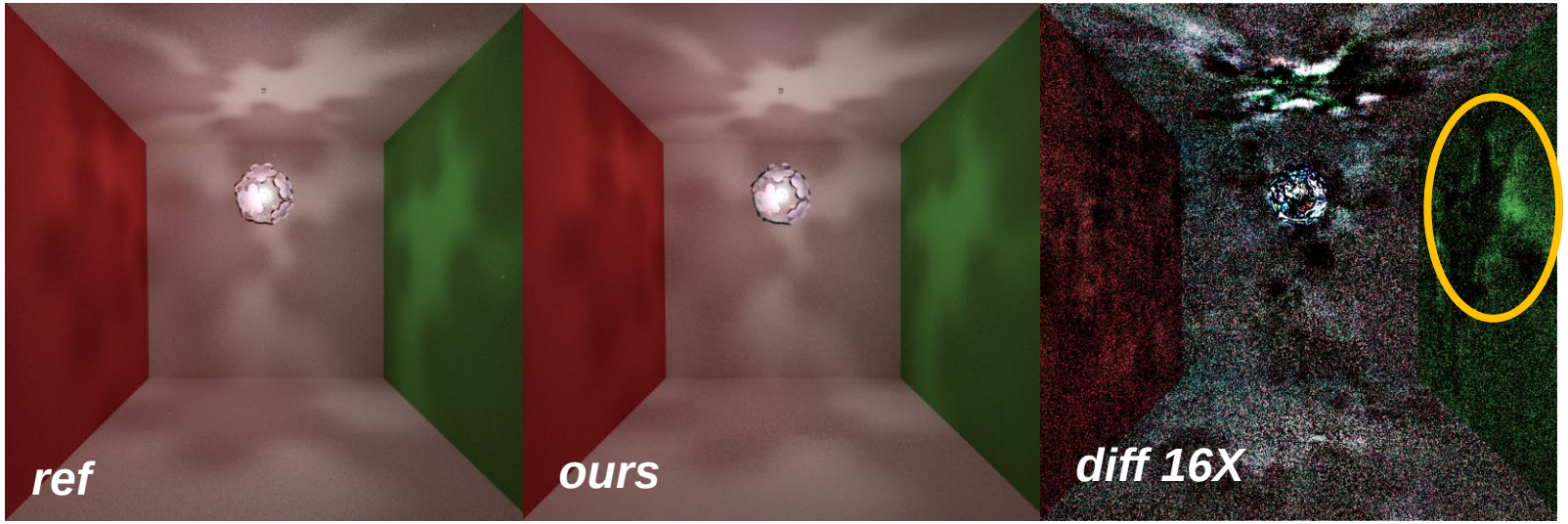
LIMITATIONS

- ***Further bias in importance sampling***



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LIMITATIONS

- ***Expensive synthetic training data***

Evaluation & Transparency network: 200 thousand unique images each
Importance sampling network: 1 million unique images

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FUTURE WORK

- ***More accurate compositing of the luminaire into the scene***
- ***Support for editing the luminaire parameters***

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